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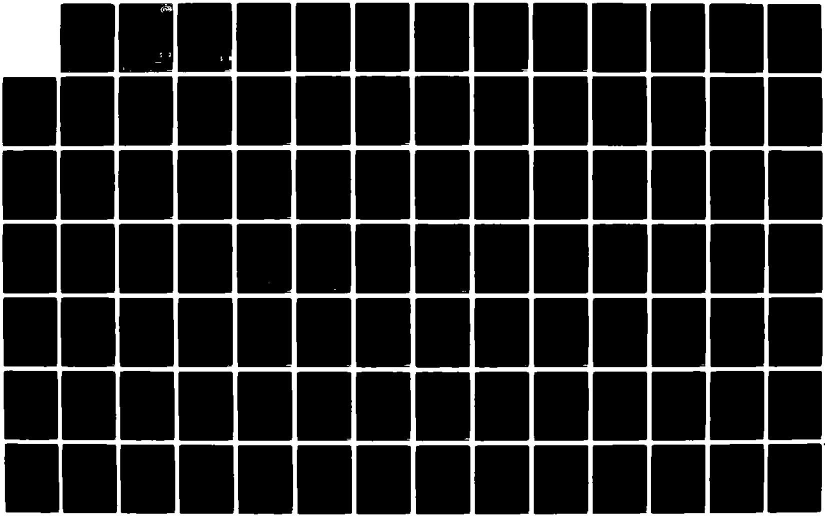

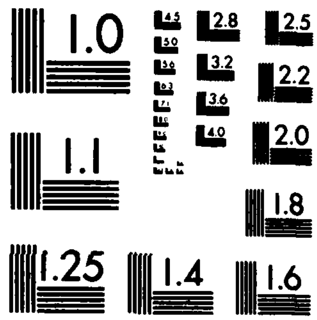

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FINAL REPORT

for the Conference on

FUTURE TRANSPORTATION ALTERNATIVES ACROSS THE

PANAMANIAN ISTHMUS

THE FUTURES GROUP

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FINAL REPORT

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FUTURE TRANSPORTATION ALTERNATIVES ACROSS THE PANAMANIAN ISTHMUS

Prepared for

The Department of State

This paper was prepared for the Department of State as part of the external research program. Views or conclusions contained herein should not be interpreted as representing the official opinion or policy of the Department of State.

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EXECUTIVE SUMMARY

Introduction

The Conference on "Future Trans-Isthmian Transportation Alternatives" was organized by The Futures Group, under contract to the Department of State, on October 13-14, 1982, in Washington, D.C. The purpose of the Conference was to assess the viability of the Panama Canal over the next 30 years and to draw conclusions and make recommendations about the appropriateness of other trans-Isthmian transportation options.

The Cc ‘erence was organized around four interrelated issues: future demand for the Panama Canal, as approximated by forecasts of trade volume and ship transits; adequacy of the present Canal in light of future demand; the costs and benefits of alternative trans-Isthmian transportation options; and recommendations to the U.S. government on research, planning, and financial needs. The point of departure for the Conference discussions was a Briefing Book, prepared by The Futures Group, which presented forecasts of trade volume for the major commodities transiting the Canal, total shipment volume, and number of ship transits. In addition, the Briefing Book included short descriptive essays on the technological and economic attributes of various alternative trans-Isthmian transportation systems.

Forecasts of Demand

The discussion of individual commodity forecasts focused on the four largest commodity groups: grain, petroleum and petroleum products, coal, and general cargo. The forecast for grain, 59.4 million tons by 2010 with an annual average growth rate of 1.2 percent, was considered by the participants to be adequate.

The forecast for petroleum and petroleum products, 36.4 million tons by 2010, was congruent with the participants' estimates.

The forecast for coal, 33.3 million tons by 2010, was considered to be overly optimistic since growth in U.S. coal exports over the next 10-20 years will be to Europe and South America and not to the Pacific Rim countries.

The participants agreed with the forecast for containerized general cargo (33.1 million tons by 2010).

Taken in total, commodity shipments through the Panama Canal were forecasted to reach 247 million tons by 2010. This forecast concurs with the Panama Canal Commission's (PCC) forecast over the same time period, and the participants considered it an acceptable forecast for planning purposes. The participants also agreed that the traffic forecast of 247 million tons for 2010 would result in approximately 17,300-17,800 ship transits per year, or 48-50 transits per day.

Adequacy of the Panama Canal

The Panama Canal Commission estimated the present capacity of the Canal is 40 transits per day, on average, and this would increase to 43 by 1985 with the improvements that are currently in the budget. A widening of the Gaillard Cut up to 800 feet could increase transit capacity to 50 ships per day. The Panama Canal Commission considers this potential capacity of 50 transits per day to be the maximum achievable, barring a radical restructuring of the Canal.

The participants were asked to assess the adequacy of the Panama Canal in light of the projected number of ship transits for 2010 (17,300-17,800 per year or 48-50 per day) and the Panama Canal Commission's assessment of maximum capacity (50 ships per day). The group was asked to make this assessment twice during the Conference and it is significant that a different conclusion was reached on each occasion.

In retrospect, it would appear that the main sources of difference arose from changing assessments of the costs of queueing and traffic diversion, future uncertainties in world trade patterns and growth, and the time that market forces would take to regulate excess demand for the Panama Canal. During the first discussion, the participants adopted a frame of reference in which market forces could ultimately balance demand with the maximum level of service that the Panama Canal could provide. The second discussion took greater account of the length of time it would take for the market to react to potential inadequacy of the Panama Canal, the costs to shippers that would be involved in lengthy queueing and traffic diversion, and the impact of future trade uncertainties on a supply-and-demand situation that has a very narrow margin for error. In light of these concerns, the panel thought that the Panama Canal would not be adequate in the year 2010.

In contrast, no conclusion or consensus was reached on the impacts of capacity problems in the Panama Canal. While the major users of the Panama Canal (Japan and the United States) may be inconvenienced from time to time by lengthy queues, it was argued that the marketplace has alternatives available, and that in a relatively short time period, demand would adjust itself to the capacity of the Canal. However, certain other countries are much more dependent on the Canal. For example, Ecuador must ship bananas through the Canal to Europe and the United States. Delays are crucial. There also may be a large negative impact on the economy of Panama in terms of lost toll revenues.

Given the situation in which largest users of the Canal are also the least severely affected by potential inadequacy, the critical issue raised, but not resolved, was who really benefits from the Canal, who will suffer most severely from inadequate capacity, and who should pay the cost to increase its capacity. This issue was discussed later in greater detail in the context of financing of transportation options.

Transportation Alternatives

The discussion of alternatives was limited to those that would not eliminate shipments of cargo from the Isthmus itself. Thus, the discussion did not include modes of transportation such as the Mexican or U.S. landbridges.

The participants addressed all of the transportation options represented in the Briefing Book. These were:

1. Landbridges
2. Overland conveyors
3. Air cargo systems
4. Slurry pipelines
5. Petroleum pipelines
6. Panama Canal modifications
7. The Lopez-Moreno plan
8. Sea-level canal.

The first four options were not considered to be practicable transportation options for the Panamanian Isthmus in the short- or medium-term. The justifications for rejecting each of these options were similar. First, carriers would have little interest in unloading their cargo on one side of the Isthmus, subjecting it to a very complex system, increasing their own liability, giving up part of their revenue and having to make costly arrangements for their cargo to be picked up at the other side. Second, each of these options involved increased handling, storage, land area control, transit time, and possibility of commodity degradation, all of which imply a high cost and a complex physical and organizational infrastructure. Third, it is not certain that the commodities which could use any one of the options are sufficiently large in volume and frequent in scheduling to allow commercial viability. Finally, for a number of these options, such as slurry pipelines and conveyors, the required technology is simply not well enough developed for the terrain and the commodities under review.

The petroleum pipeline alternative was not considered to be a true "option" to be discussed within the Conference since such a pipeline already exists and is beginning to operate as part of the present trans-Isthmian transportation system. Furthermore, the participants agreed that the petroleum pipelines, as with the first four options discussed, would most likely result from private financing and construction initiatives and should, therefore, not be featured in a Conference designed to guide the U.S. government on transportation alternatives requiring government planning or sponsorship.

The Panama Canal modifications involve both nonengineering and engineering options and are aimed at reducing the present Canal's potential capacity problem rather than developing new transportation systems. The primary nonengineering options are toll increases and changes in transit procedures. Toll increases could relieve the capacity problem by diverting a segment of Canal traffic to alternative non-Isthmian routes. Tolls could be increased either evenly across-the-board or on a discriminatory basis, according to ship size. Both options conflict with PCC operating policy. An across-the-board toll increase would be a departure from the PCC's break-even toll-rate schedule, and under current law, a discriminatory toll schedule that favors larger ship transits is not legal. However, the real question is not whether toll options are consistent with current policies or laws, since these can be changed, but rather, whether pricing to drive away traffic would be a desirable alternative. The participants agreed that increasing tolls, particularly on a discriminatory basis, would reduce demand. No agreement was reached on the desirability of this option.

With regard to changing transit procedures, the PCC outlined two possible procedural changes: switching to one-way traffic on a continuous basis for a few days, with the reverse procedure on subsequent days, and increasing the efficiency of handling ships in and out of the locks. Both changes are under investigation at

the PCC. However, the resulting increase in capacity is not likely to be significant enough to accommodate projected demand.

The engineering modification of the Panama Canal involves first, widening the Gaillard Cut. The range of the project would include: (1) a $200 million widening of the Cut to 600 feet, without any change in alignments, (2) a $500 million project to increase the Cut to 800 feet with a change in alignments. This project would increase capacity to 50 ships per day.

The Lopez-Moreno plan involves a radical restructuring of the Panama Canal. The principal elements of the plan are

- the widening and deepening of the entire navigational Canal, from the Island of Tobago to a point beyond the Atlantic breakwater.
- the construction of new locks and improvements to existing locks at each lake terminal.
- the implementation of a water-management strategy that will optimize the use of water within the actual hydrographic basin of the Canal and adjacent basins.

Each of the elements can be done in separate stages. The construction cost of the entire plan is $3.9 billion without interest charges, or $7-$8 billion with interest charges. This plan is expected to place capacity at 40,000 ships per year and would be able to handle ships up to 150,000 dwt.

The sea-level canal plan requires the construction of a new canal along Route 10 (determined to be the best route by the 1970 Interoceanic Canal Study Commission). The canal would have one tidal gate, multilane traffic, and the ability to transit the largest ships, including canted-deck aircraft carriers. The major problems with the plan are environmental and cost. No one can accurately estimate the environmental impact of mixing Atlantic Ocean and Pacific Ocean biota. The cost was estimated in 1970 at $2.8-$2.9 billion and current estimates range from $15 billion to $20 billion, including interest charges.

Areas of Government Concern/Action

Any comparative assessment of transportation alternatives should make the distinction between economic need and financing feasibility. The need for a new or improved Canal apparent in commodity projections and the Conference consensus does not necessarily produce the requisite financing, given the problem of who is going to underwrite any improvements or changes until a cash flow from toll charges begins.

With regard to economic viability, rough calculations we e made to show capital costs in relation to the increase in capacity realized various options. There was disagreement with these calculations. Some partic nts felt that a major Canal project (Lopez-Moreno), would stimulate significan ases in trade that utilize the new capacity, thus justifying itself in the long run. It was pointed out, on the other hand, that any project requiring a significant capital outlay could only be justified by the anticipation of a "quantum" leap in trade. Some participants felt it was difficult to foresee a doubling or tripling of trade through the Isthmus over the next 30 years.

Option	Cost	Capacity Increase	Cost/Ton
1. Pipeline	$200 m	50 m tons	$4 m/ton
2. Widening of Gaillard Cut	$500 m	40 m tons	$12.5 m/ton
3. Lopez-Moreno with interest costs	$8.0 b	250 m tons	$32 m/ton
4. Sea-level canal with interest costs	$20 b	250 m tons	$80 m/ton

On the issue of financing, the participants reviewed the most likely available funding mechanisms. The PCC was not considered to be a promising source of funds for new projects. By law, the PPC cannot borrow money. Its only means for raising funds is to increase tolls. However, any scheduling of the tolls above the

break-even basis would be an unacceptable departure from traditional operating policy.

Other financing options include:

- Country guarantees of loans, in which a country with a strong economy and access to private capital markets, such as the United States or a consortium of countries, might guarantee a loan to Panama

- Financing through development banks

- Government subsidies justified by defense considerations (this option was seen as highly unlikely)

- Loan guarantees by the larger users (private sector).

The major problem which reduces the acceptability of any of these options is identifying who benefits from improvements to trans-Isthmian transportation facilities, and apportioning the cost of the project(s) to the beneficiaries. Although the participants agreed that some sort of international cost-sharing arrangement was the only way to approach the financing issue, likelihood of consensus among several potential lenders concerning the allocation of risk and reward was regarded as low.

The participants identified several crucial topics that should be of interest to the U.S. government in policy planning for the Panamanian Isthmus:

- Cost estimates: identify and justify the need, cost, and cost overrun allowances for each project

- Funding: identify and develop financing arrangements, if appropriate

- Political understanding: identify the relevant political constituencies and their political climates

- Planning process: develop a planning process that will enable the U.S. government to review the options at the appropriate times in order to make decisions

- Environmental impact studies for the sea-level canal as well as the third-locks options (Lopez-Moreno).

Turning more specifically to the upcoming negotiations on the terms of reference for a feasibility study on the sea-level canal, the participants offered the following recommendations for the Preparatory Committee:

- There should be a mapping of key benchmarks and lead times to allow for the pacing of decisions.

- Commodity forecasts should be made for the period beyond the year 2000, taking into account the transfer of ownership of the Canal to Panama.

- There was disagreement among the participants as to whether defense considerations should be included in the terms of reference.

- A more complete investigation of the financing options available for any improvement or modification is required.

- There is a need to develop updated cost estimates for all options.

- It will be important to establish information on the ship mix and transit times for ships that use the Canal.

- An assessment of the operating rules and philosophy of the Panama Canal Commission (e.g., break-even toll structure) should be reviewed.

- Any project requiring U.S.-appropriated funds should carefully assess the environmental impact of that project.

- An entire project overview must be made, and it should define where more detailed analysis is needed.

- The main issue is the transit capacity of the Isthmus. Therefore, the subject of investigation should be whether a larger Canal or enlarged transit capacity is needed, not whether a sea-level canal is needed.

I. INTRODUCTION

The following report is comprised of information obtained as part of The Futures Group Conference on "Transportation Alternatives Across the Panamanian Isthmus" held under Department of State auspices on October 13-14, 1982, in Washington, D.C. The Conference was designed to provide the United States government with information concerning trans-Isthmian transportation options in order to aid the policy planning process. In addition, the information is to be used by the Department of State in the upcoming meeting with representatives from the Panamanian and Japanese governments in a Preparatory Committee meeting to discuss the terms of reference for the feasibility study required by the Panama Canal Treaty.

The report is an analytical summary of the Conference deliberations. It is divided into two main sections. The first is the October 13-14 Conference material, which includes an Executive Summary, an explanation of the Conference structure and the goal of each session and a summary of the Conference discussions. The Conference discussion results have been organized on a subject basis that reflects key areas of discussion. It was felt that organizing the summary on a topic basis rather than on a chronological basis would be more helpful to those interested in trans-Isthmian transportation alternatives who did not attend the Conference.

The second section is part of the pre-Conference Briefing Book prepared by The Futures Group for the Conference participants and used as a point of departure for all discussions. The material includes forecasts of individual commodity groups, total commodity shipments, number of ship transits and essays on several

transportation alternatives. This material is included to provide readers with the background material that the participants used in preparing their remarks at the Conference.

The purpose of the Conference report is to provide an accurate summary description of the discussions for the Conference participants and observers (especially the Department of State, the Panama Canal Commission, and other government departments and agencies concerned with trans-Isthmian alternatives) and for those countries, companies, institutions and individuals with long-standing interests in the future of the Panama Canal.

It is crucial to emphasize that the contents of the report are limited only to conclusions that could be reached at a two-day Conference and as such do not always contain definitive answers to the transportation questions posed for the future of the Panamanian Isthmus. The Futures Group study team has deliberately avoided trying to force consensus in its analysis and instead has presented only its understanding of the Conference deliberations.

Finally, The Futures Group study team would like to thank Ely Brandes for his contributions to the study.

Conference Structure

The Conference on "Future Trans-Isthmian Transportation Alternatives" was organized to assess the viability of the Panama Canal over the next thirty years and to draw conclusions and make recommendations about the appropriateness of other transportation alternatives. The Conference endeavored to answer several crucial questions.

1. What will the role of the Panamanian Isthmus be in world trade patterns in light of the advancement in transportation technologies over the next thirty years?
2. Will the Panama Canal be adequate to handle the level of shipping traffic expected over the next thirty years?
3. If the Panama Canal is inadequate for projected commodity demands, what will be the effect on world trade and on the particular commodity markets?
4. What are the additional transportation alternatives available in conjunction with the Panama Canal that will be capable of transporting the expected level of demand for trans-Isthmian transport?
5. What are the characteristics of these transportation alternatives?
6. What additional information is needed to make future policy choices?

The Conference convened an eclectic group of experts to address these questions. The experts included executives from companies that use the Panama Canal, transportation engineers, relevant experts from foreign and U.S. governments, international economists, private sector and World Bank financial consultants, present and former officials of the Panama Canal, individuals with knowledge on alternatives to the Panama Canal, shipping firms and defense analysts. The Futures Group acted as facilitator in the Conference in order to aid the participants in deciding on the key issues.

The Conference was structured to investigate the key questions sequentially. The first task was to ascertain whether the Panama Canal will have the capacity to handle projected demand of traffic over the next thirty years. The assessment of the future viability of the canal began with an examination of the volume of commodities that will use the canal in the future. The commodities were divided into eleven groups, and forecasts were then prepared in order to project total demand for the Panama Canal. These commodity groups included grains and soybeans; petroleum and petroleum products; coal and coke; metals; ores; phosphates and fertilizers; lumber, pulp and paper; bananas; miscellaneous bulk material; automobiles; and general cargo. By aggregating the eleven commodity groups a figure for total demand was obtained. The total was then used to determine the mix of ships that will utilize the Panama Canal and whether the Panama Canal capacity will be exceeded.

The Conference participants were asked to assess the impact and consequences of the Panama Canal not being able to handle future demand. The participants were requested to evaluate the impact of exceeding Panama Canal capacity on such areas as world trade, country markets and the particular commodity markets involved. As a result of the conclusions reached, the Conference participants deemed it appropriate to review the transportation options that could alleviate future strains on the capacity of the Panama Canal.

The Conference participants were then asked to discuss the alternatives presented and to expand or modify the list of alternatives. The participants added more complete information and generally discussed each alternative that the group felt was appropriate. The range of alternatives discussed included not only engineering (structural) options, e.g., modifications to the canal, constructing a sea-level canal, use of pipelines or conveyor belts, etc., but nonengineering (nonstructural) options that increase the capacity of the canal, e.g., changing

transit procedures, increased tolls, were also appropriate for discussion at this time. The participants discussed all relevant and realistic options and attempted to assess the characteristics of each.

In conclusion, the Conference participants were requested to identify the problem areas in choosing alternatives to expand the capacity of the Isthmus. Consideration was given to the potential impact of problem areas on assessing the demand for trans-Panamanian transportation, on the need for and direction of further studies, and on recommendations for next steps in policy planning. A more complete discussion of the Conference sessions is included in the next section.

Conference Sessions

This first session was devoted to a discussion of the Panama Canal traffic projections made in the Briefing Book, both in terms of commodity volumes and ship numbers. The discussion focused on the following points.

1. Are the projections reasonable? If not, why not?

2. Do they signify some level of inadequate Panama Canal capacity?

3. If so, how large is this capacity shortfall? 10%? 30%? 50%?

4. When will the capacity limitation become apparent?

5. Assuming that nothing is done to increase the transit capacity of the Panama Canal, what adjustments will the marketplace make to equalize supply and demand?

6. What effect will such adjustments have on individual countries? (Will the effect be serious, very serious or negligible?)

   a. on Panama
   b. on the United States
   c. on other large users of the Panama Canal, such as Japan
   d. on less developed countries
   e. on total world trade, or any significant segment thereof.

The goal of this session was to reach a common understanding of the economic impact that is likely to result from a capacity limitation at the Panama Canal, how large that impact is likely to be and who will be primarily affected by it.

The second session of the Conference was devoted to an enumeration of alternatives available to increase the transit capacity of the Panamanian Isthmus. This enumeration included both engineering and nonengineering alternatives. (However, they did not include alternatives that would simply eliminate shipment from the Isthmus.)

Included among the alternatives were at least the following:

<u>Nonengineering Alternatives</u>

1. Raising tolls to reduce traffic
2. Changing transit procedure to allow more transits per day.

<u>Engineering Solutions</u>

1. Another canal, presumably a sea-level canal
2. Modifications of the Panama Canal, via third locks or otherwise, to increase transit capacity, both in ship numbers and size of ships
3. Construction of non-canal facilities such as pipelines, conveyor systems, to divert some commodities from the Panama Canal.

These alternatives were subjected to a thorough qualitative analysis in the next session. However, initially the group developed some immediate appreciation of the degree of improvement that a given alternative might provide. The purpose of this session was to reach a common understanding of the various alternatives available to increase the transit capacity of the Isthmus and of the degree of improvement that is likely to result from each alternative.

The focus of discussion in the third session was an objective assessment of the alternatives identified in terms of specific characteristics. The assessment was considered "objective" because it did not involve any choosing of an alternative for implementation. Rather, the assessment related to certain measurable features that need to be kept in mind before actual choices can be made or recommended.

The following measurable features were used for the assessment:

1. Cost. Very broad ranges; like less than $100 million; up to $1 billion, etc.

2. Financing. Where would the capital necessary for any given project come from?

3. Time required. There would be range estimates of all the time required from conception to completion.

4. Degree of multilateralism. How many country agencies, groups, etc., must agree before an alternative is implemented?

5. Degree of appropriateness. Is the transit capacity of a given alternative enough/too much/appropriate to relieve potential Panama Canal capacity insufficiency?

6. Environmental impact. What will be the impact of these alternatives on the environment?

7. Defense considerations. What will the alternatives mean to U.S. security interests?

8. Benefits. What are the advantages of any transportation alternatives?

The principal result sought in this session was a common appreciation of the fact that there are vast differences among alternatives in terms of cost, canal capacity, time required, ease of introduction, which obviously would affect the likelihood that any recommended alternative will in fact be chosen.

The principal focus of the final session was to discuss some aspects related to the process of aiding the U.S. government in making policy decisions for expanding the capacity of the Isthmus. In doing this the following subjects were addressed:

1. Do we know enough issues to make a reasonable choice of an alternative?

2. If not, what are the significant knowledge gaps that prevent the making of a choice? How should such knowledge gaps be filled?

3. What other impediments exist that prevent making a choice of an alternative?

4. Based upon the apparent results of the Conference, what actions should the government take to bring the issues developed here closer to resolution?

5. What first step or steps are appropriate or necessary to begin a planning process which has as its goal the development of facilities necessary to expand the transit capacity of the Isthmus?

6. What recommendations should this Conference make in furtherance of this objective?

II. CONFERENCE DISCUSSIONS

Introduction

The following pages contain an analysis of the Conference discussions organized by substantive topic. It is intended to identify major areas of consensus and to highlight unresolved issues that may require further study.

Trade Forecasts

a. Grain. The major consideration for grain shipments going through the Panama Canal is transportation cost. While the alternatives of using Gulf ports and the Panama Canal or using West Coast ports appear to be economically competitive, there is presently an oversupply of barges on the Mississippi River which has depressed barge freight rates. The low barge freight rates appear to be only a short-term phenomenon and, in the long term, as this market stabilizes, more traffic will be diverted away from the Canal to use U.S. railroads and West Coast ports. A key question is how long the oversupply of barges will last. The discussion ranged anywhere from two to ten years.

The forecast of grain shipments through the Panama Canal is based on a growth rate of 1.5 percent per annum. The participants' estimates range around 1-2 percent per year growth for the forecast period and they do not expect shipments to increase substantially over the forecast period. The potential for growth of U.S. grain exports through the Canal to the Far East depends on several factors: (1) the nutritional variety required by Far East nations; (2) the political expediency of buying "people grain"; (3) the movement of grain out of Louisiana ports; and (4) most important, the Chinese allocation of resources to produce a modern

agricultural system capable of providing for domestic demand and also able to export grain. China is presently the second largest producer of grain in the world, but is also a major importer. The key question here is whether the Chinese will be able to provide grain for themselves and other Asian nations. If so, this will have the effect of reducing U.S. shipments of grain through the Panama Canal. The feeling of the group was that the estimates for growth in Chinese production of grain were too high.

Another important consideration for grain shipments will be the mergers that are currently occurring in the U.S. railroad industry. These mergers will make U.S. railroads a more economically competitive alternative to the Canal.

Conclusion: The participants thought that while the forecast is basically accurate, it may be slightly optimistic since it did not take into account the fact that the present surge in grain traffic through the Canal is an anomaly resulting from the oversupply of barges on the Mississippi River system. The crucial factor in the future of grain shipments will be transportation costs. If the oversupply along the Mississippi disappears in the long term, more grain will be going out of the West Coast ports and less through the Canal. The Futures Group has adjusted the forecast to reflect this factor.

b. Petroleum. Petroleum shipments through the Canal have peaked and will continue to decline during the forecast period by as much as 2 percent per annum. The key variables for petroleum shipments through the Canal are (1) the amount of Alaskan oil produced and refined; (2) the level of foreign oil from Indonesia and the Persian Gulf to California; and (3) alternative transportation systems, specifically the trans-Panamanian pipeline.

Since the economics of shipping petroleum through the pipeline are better than Panama Canal economics, it is likely that only a small amount (50,000 bbl) of Alaskan oil will use the Canal.

Conclusion: While there was disagreement with the short-term forecast of petroleum shipments, the 2010 forecast was accepted by the Conference participants as reasonable.

c. Coal. The coal forecast was thought to be optimistic since the growth in coal exports over the next 10-20 years will be to Europe and South America and not to the Pacific rim countries. Japan will import its coal from China and Australia, and the United States will be used as a "safety valve" supply source. As a result there will be only modest growth in coal shipments through the Canal.

An important distinction was made between coking coal and steam coal. Coking coal, exported from Hampton Roads, Virginia, to the Far East for steel making, is not expected to be a growing export commodity for the United States because of competition from Australia and Canada. For steam coal shipped both from West Coast ports and through the Canal, the market is expected to increase. However, it will not grow by very much (50 percent over the 30-year forecast period). While there was general agreement on modest growth in the steam coal market, it was pointed out that it is a volatile market and a complex commodity to forecast.

Conclusion: The participants thought that the growth in coal shipments through the Canal would not be as high as the original forecast.

d. General cargo. The forecast for containerized general cargo was thought to be adequate. There was some disagreement concerning the level of containerized cargo that would be diverted to mini- and landbridge routes. However, the group felt this would not have a significant effect on the total forecast since it was already taken into account in making the forecast.

Conclusion: The group agreed with the forecast for general cargo. They noted that the category was an amalgam of diverse products, and it would be difficult to obtain complete agreement on the future level of such shipments through the Canal.

e. Other commodities. Phosphates and Fertilizers: U.S. shippers have begun to reduce exports. This will decrease shipments through the Panama Canal.

Iron Ore: Large quantities (10 million tons) of iron ore will be shipped to Japan from Brazil that may not utilize the Canal. However, it was pointed out that if the Canal could accommodate large ore carriers, these shipments might go through the Canal.

Total Commodity Shipments

There was general agreement that the level of total shipments (247 million tons) was in line with the Panama Canal Commission's forecasts over the same time period, and that it was an acceptable level for planning purposes. It was pointed out that by going through the forecasts on a commodity-by-commodity basis, minor disagreements with the projections would not have a significant effect on the total, since the reduction in some commodities would be balanced by increases in others.

Conclusion: The group thought traffic projections over the 30-year period were uncertain at best (particularly since there are currently available transportation alternatives to commodity flows through the Panama Canal). There also will be new commodity flows that can be estimated only tentatively from past trends. As a result, it appears reasonable for planning purposes, at this time, to expect a gradual growth in traffic to about 250 million tons for 2010.

Ship Transits

The group agreed that the traffic forecast of 250 million tons for 2010 would result in approximately 17,300-17,800 ship transits per year, or 48-50 transits per day. The Panama Canal Commission estimated the present capacity of the Canal is 40 transits per day, on average, and this would increase to 43 by 1985

with the improvements that are currently in the budget. A widening of the Gaillard Cut up to 800 feet could increase transit capacity to 50 ships per day. The Panama Canal Commission considers this potential capacity of 50 transits per day to be the maximum capacity achievable for the Panama Canal, barring a radical restructuring of the Canal such as that envisaged by the Lopez-Moreno plan.

Adequacy of the Panama Canal (in terms of ship transit numbers)

The participants were asked to assess the adequacy of the Panama Canal in light of the projected number of ship transits for 2010 (17,300-17,800 per year or 48-50 per day) and the Panama Canal Commissions's assessment of maximum capacity (50 ships per day). The group was asked to make this assessment twice during the Conference and it is significant that a different conclusion was reached on each occasion. The source of the difference lay in the lack of specificity in the definition of adequacy and the resulting factors that were considered during the discussions.

During the first discussion, the participants were simply asked to assess the Canal's adequacy. No frame of reference was given as to which present and potential Canal improvement projects should be taken into account. There was also no prior attention given to how "adequacy" should be defined. There were several key points raised during the discussion. First, it was emphasized that forecasting the adequacy of the Canal is a tenuous exercise at best since it requires many assumptions about ship type and size, and the type of commodities that would use the Canal. Second, it was pointed out that for each commodity that uses the Canal, there exists an economic alternative to transport the goods and that this alternative is currently being used. These options are available, for example, for grain, lumber, coal, iron ore and bananas. Third, a few participants felt that the Canal does not have a fixed capacity, and therefore what should be

looked at is the level of service at which the Canal traffic starts to decline. It was pointed out, however, that some traffic is insensitive to the level of service. Other traffic is insensitive to a range of service levels and might decline rapidly if the level of service declines past this window. Yet even in the latter case, the rapidity of changes in trade patterns will depend in large part on the degree to which that trade is tied up in long-term contracts (it was suggested that a great deal of foreign trade is) and therefore insensitive to service levels below "the window." Finally, it was pointed out that in talking about adequacy one should look at the Panama Canal in the context of total transportation systems moving cargo from one point to another. If looked at in this way there is no inadequacy with the Panama Canal, since cargo can be transported in a number of ways from one point to another. The point was made that some of the constraints mentioned in terms of adequacy of the Canal, e.g., ship size, are constraints on the entire shipping industry. Even if the Canal were larger, there are constraints in port size and infrastructure that make it impossible to handle large ships.

The general consensus of the first discussion was that there may be greater queueing at the Canal in 2010, but that market forces would act as a natural regulator of traffic. Therefore, the group concluded that the Canal would be capable of handling the demand forecasted for 2010.

During the second discussion, the participants were asked to limit their consideration of Canal capacity to only that capacity which can be realized through Canal improvements that are presently planned and budgeted. In addition, the participants were asked to consider the definition of "adequacy" and whether diversion of traffic by market forces due to queueing, lengthening of transit times, or toll increases at the Canal should be taken as indications of inadequacy.

The participants raised several points in regard to the definition of adequacy. First, it was felt that the Panama Canal only reaches a level of inadequacy when

traffic begins to divert to other alternatives. Therefore, the diversion of commodities by market forces indicates a certain level of inadequacy. It was pointed out that queueing does not imply inadequacy since traffic has not been diverted. On the other hand, queueing does involve a cost to the shipper which, for some commodities, may necessitate diversion. On average, diversion occurs when queueing time exceeds 48 hours or when there are more than 130-140 ships in the queue.

Secondly, it was pointed out that adequacy can be discussed in terms of ship size. There are certain sizes of ships that presently cannot pass through the Panama Canal. It was felt by some that the Canal will constrain the growth of some ships that are planned for the routes that use the Canal; others felt that port size and infrastructure would represent similar constraints regardless of the Canal.

In order to get an accurate feeling of the group's opinion on this subject, a CONSENSOR vote was taken. The CONSENSOR is an electronic voting tool designed to assist the decisionmaking process. The device enables all participants in a discussion to express anonymous opinions about a subject on two dimensions: (1) agreement or disagreement with a statement on a scale that ranges from 0 to 10 (0 equals no; 10 equals yes), and (2) weighting of expertise on the subject on a quartile basis (0 to 100 percent).

The vote was taken on the question, "Will the Panama Canal be adequate to meet projected demand in 2010?" The first vote resulted in a 2.4 level of agreement and an expertise rating of 80 percent. The group gave reasons for their votes and a second vote was taken to determine if the discussion had an effect on the voting. The second vote had a level of agreement of 2.1 and an expertise rating of 82 percent (see page 129). The vote reflected an overwhelming feeling that the Panama Canal would not be able to handle the projected traffic demand.

In retrospect, it would appear that the main sources of difference in the conclusions reached an adequacy during each discussion arise from changing assessments of the costs of queueing and traffic diversion, future uncertainties in world trade patterns and growth, and the time that market forces would take to regulate excess demand for the Panama Canal. During the first discussion, the participants seemed to utilize a frame of reference in which market forces could ultimately balance demand with the maximum level of service that the Panama Canal could provide. The second discussion took greater account of the length of time it would take for the market to react to potential inadequacy of the Panama Canal, the costs to shippers that would be involved in lengthy queueing and traffic diversion, and the impact of future trade uncertainties on a supply and demand situation that has a very narrow margin for error. In light of these concerns, the panel thought that the Panama Canal would not be adequate for the year 2010.

Impacts of Capacity Problems

The major users of the Panama Canal are Japan and the United States. While they might be inconvenienced from time to time by lengthy queues, the marketplace has alternatives available, and in a relatively short time period, demand will adjust itself to the capacity of the Canal. However, certain other countries are much more dependent on the Canal. For example, Ecuador must ship bananas through the Canal to Europe and the United States. Delays are crucial. There also may be a large negative impact on the economy of Panama in terms of lost toll revenues.

Conclusion: The major issues of debate in this section were who benefits from Panama Canal traffic and who should pay the cost of improvements to increase its capacity. No conclusion was reached on these points.

Transportation Alternatives

The discussion of alternatives was limited to only those that would not eliminate shipments of cargo from the Isthmus itself. Thus, the discussion did not include modes of transportation such as the Mexican landbridge or the minibridge across the United States.

1. Non-Engineering Options

a. A toll increase. The use of toll increases to divert traffic and hence reduce demand for the Canal was considered as a means of reducing a potential capacity problem. It was stated that the Panama Canal Commission operates on a break-even basis, and as a result it has developed a break-even toll schedule. An increase in tolls beyond the break-even point would be a departure from its traditional mandate and operating policy.

Another option is to charge tolls on a discriminatory basis, based on ship size or commodity type. This could increase capacity by influencing the mix of commodities and the size of ships going through the Canal. However, as the laws pertaining to the Panama Canal presently stand, discriminatory toll pricing is not legal. The discussion centered on whether, from an economic perspective, it should be considered an option and hence require a change in law. Some participants felt that the toll structure is going to have to change and that the small ship would have to pay higher toll charges or else there would have to be an expansion of the Canal. This is a multi-billion-dollar decision. As the Panama Canal reaches capacity, the Commission will inevitably have to do something to that toll structure. There was a feeling that the free market should charge what the traffic is willing to bear. The very act of increasing tolls will reduce traffic.

Conclusion: The real question is, Should the Panama Canal Commission look at a toll pricing system as an alternative to doing nothing? There was disagreement as to whether pricing to drive away traffic would be a desirable alternative.

It was felt that the current legal constraints mentioned should not be considered in our discussions of this session. As a result it was agreed that increasing tolls in a nondiscriminatory manner may be used as an effective way of controlling demand.

b. Changing transit procedures. The Panama Canal Commission explained two options of changing transit procedures. One allows for one-way traffic on a continuous basis for a few days and then the reverse procedure on subsequent days. However, it was pointed out that the capacity gained in two days of one-way traffic is lost in switching to the other direction. A second procedure is to decrease the handling times in and out of the locks. At the present time, the Panama Canal Commission is doing studies to ascertain what will be the most efficient methods of handling ships.

Conclusion: It was felt there is very little the Panama Canal Commission can change in the transit procedures to increase capacity significantly enough to make a difference in the maximum number of ships that can be transited.

2. Engineering Alternatives

a. Pipelines. There was limited discussion of the pipeline option since it was felt to be an existing part of the Panamanian Isthmus infrastructure, and if there were economic justification for a new pipeline (a major oil find) it would be built.

The pipeline is currently running in a south-to-north direction, and it may be possible to reverse direction if petroleum is available from the East Coast. The pipeline was constructed with a three-year payout.

Conclusion: The pipeline is not a boon to the Canal. In the short term, it will reduce the capacity problem but will not be beneficial as a long-term solution in terms of revenues. The analogy was made that if users continue to take away key commodities from the Panama Canal, it would be like skimming the cream off the top. The result would be the need to increase tolls.

There are negative economics associated with increasing the capacity of the Panama Canal as opposed to building the pipeline. As soon as a homogenized

product with a single destination is identified, alternatives will come into play. The Alaskan oil and the pipeline are examples. The pipeline was built for about $200 million, and it can transport 45-50 million tons of cargo per year. It is impossible to increase the capacity of the Panama Canal by 45-50 million tons per year with an investment of only $200 million. The dollar requirements per ton of cargo will be higher for the Panama Canal improvements. The economics of the pipeline will always surpass the economics of any kind of canal alternative, including improvements in the present Panama Canal.

b. Slurry pipelines. The participants were unsure about whether both steam and metallurgical coal could be slurried. Metallurgical coal must be transported in whole-load slugs. However, slurry slugs are impractical for anything as small as 15,000 ton cargoes. A further problem associated with slurry systems across the Isthmus is that pipelines are energy intensive in moving bulk commodities. Also, there is a problem with extracting water from coal. Brown & Root, Inc. has spent a significant amount of resources and time in studying the feasibility of a slurry pipeline in Panama and has given up on that project because it is not economically feasible.

Conclusion: Slurry pipelines over the Isthmus are not viable alternatives at this point, neither technologically nor economically.

c. Overland conveyors. As an addition to the essay, it was pointed out there are significant cost and technological factors involved with an overland conveyor system that have not been adequately discussed. These include handling costs, storage needs and their cost, degradation of the commodity, land area control, the number of storage piles required of such a large system, etc. There is a substantial dollar cost per ton for each of these constraints. Another problem is that commodity mixtures on a single conveyor system would result in contamination of each commodity. In addition, mechanical difficulties are more likely on a conveyor

system than on the other alternatives. Finally, there is a dust and air quality control problem that must be solved.

Conclusion: The participants thought it would not make sense for a ship to unload its cargo on one side of the Isthmus, subject it to a very complex system, and then reload it onto another ship on the other side. It was pointed out that this might be feasible only in the short term if the Panama Canal were not operational. An overland conveyor system was not considered to be feasible for the Isthmus because of technological, logistic and economic difficulties.

d. Landbridge. A key point in favor of the landbridge was that it might be able to save time in passing cargo across the Isthmus. However, it was also noted that container ships with 1,500 containers which would have to be unloaded and then reloaded might lose time and increase costs. Carriers would have little interest in giving up their cargo, increasing their own liability, giving up part of their revenue and having to make costly arrangements for their cargo to be picked up at the other end. The Panama Canal Commission explained it had just completed a survey of 30 customers from Europe who could potentially use a landbridge, and they did not find potential users for Mexico's landbridge, except the Mexican users themselves. The key consideration for the landbridge was price. A 20-foot container holds 19 tons, which translates into approximately $30-$40 per ton in Panama Canal tolls.

Conclusion: The group thought it is difficult to envision how a landbridge option would have a tremendous impact on the Panama Canal. The Panama Canal Commission has looked at this project since 1970 and has not found it to be economically viable.

e. Air transportation. The group felt that air transportation was not a viable option. However, it may be appropriate in the future under certain circumstances for certain agricultural commodities. There was no support for an air transportation system across the Isthmus.

f. Canal alternatives.

1. Widening of the Gaillard Cut. This project would allow a two-directional traffic flow and would also utilize the locks more effectively. The widening, combined with the internal Canal improvements, will place capacity at 50 ships per day. Of these 50 ships, 65 percent of the vessels could have beams greater than 80 feet (up to Panamax size). If the widening project is agreed upon, the project must be completed within 10 years. The widening costs range from $200 million to $500 million in current dollars. The Panama Canal Commission felt they could save on engineering costs if the project were done in a shorter period of time. The range of the project would include: (1) a $200 million widening of the Cut to 600 feet that would not involve any change in alignments, (2) a $500 million project to increase the Gaillard Cut to 800 feet with a change in alignments. These are understood as two distinct projects. It was pointed out that the $500 million project increases the capacity by 7 ships per day. This is equal to 2,000 more transits per year. With $40 million per year additional revenue, the capital costs of 10 percent would result in a 20-year payback. A key point is that the project is economically marginal, in real terms; as it exceeds $500 million it gets more difficult to justify.

2. The Lopez-Moreno Plan. The principal elements of the plan are:

- the widening and deepening of the entire navigational Canal, from the Island of Tobago to a point beyond the Atlantic breakwater.

- the construction of new locks and improvements to existing locks at each lake terminal.

- the implementation of a water-management strategy which will optimize the use of water within the actual hydrographic basin of the Canal and adjacent basins.

The cost estimates for this plan have recently been verified by a U.S. firm at $3.9 billion in construction costs to do the whole project. The plan can be done in stages: the widening can be done now and the channel can be deepened later for

150,000 dwt ships. The capacity of the Canal if this plan were to be put into effect would be 40,000 ships per year. Given the forecasts, the cost of this project could not be recovered from tolls.

3. The Sea-Level Canal. John Sheffey, former Executive Director of the Interoceanic Canal Study Commission, gave a brief exposition of the research done on a sea-level canal in 1970. The Commission concluded that if a sea-level canal were to be constructed, the ideal location would be in Panama along Route 10. It was estimated that the cost of a sea-level canal in 1970 dollars was $2.8-$2.9 billion. Two key points in favor of the sea-level canal are related to defense. First, it can be bombed but not destroyed. Second, it could be used to transport canted-deck aircaft carriers between the Pacific and Atlantic oceans. There was concern that there would be an environmental problem of mixing the Pacific and the Atlantic Ocean biota. The group thought at this point no one can accurately estimate exactly what would be the outcome of mixing the Atlantic and Pacific oceans. An environmental impact study would be required on any project that would use U.S.-appropriated funds (such as the sea-level canal).

Shipping Trends

While historically the trend in average ship size has tended to increase for all types of ships, the group thought it was unlikely that all ship types will continue to get larger, and that there are various constraints to ships getting larger: these include the Panama Canal and the size and infrastructure of ports for handling larger ships.

In addition, shipowners would want to reduce the economic risk of shipbuilding and as a result would tend to make the vessels small enough to utilize all key transportation arteries, including the Panama Canal. This would tend to limit the growth in average size ship.

Defense Considerations

A sea-level canal is presumably less vulnerable to terrorist attack and easier to repair in case of subversion. It is also the only option capable of handling large canted-deck aircraft carriers, which would allow substantial savings on the development of a two-ocean Navy. It was pointed out that the Navy has three options vis-a-vis its fleet and the sea-level canal: (1) a two-ocean fleet with a sea-level canal; (2) a two-ocean fleet without a sea-level canal; or (3) a one-ocean fleet with a sea-level canal. The Navy has never publicly supported option 3; instead, it would prefer option 1. The Navy will not give up carriers in support of a sea-level canal. Consequently, while there is a defense interest, it is not likely to emerge in terms of the Defense Department supporting the sea-level canal by devoting resources for its construction. The group felt the Navy was unwilling to give up anything for the construction of a sea-level canal.

As long as the aircraft carrier task force continues to be a principal factor in the structuring of U.S. naval surface forces, the existing Panama Canal will have limited utility for interocean movements of U.S. warships. Moreover, although some escort ships might transit the Canal separately, their removal from a task force would obviously increase its vulnerability. Therefore, the naval utility of an expanded or alternative canal would depend upon the extent to which it could accommodate aircraft carriers.

The existing Panama Canal does provide a means for shuttling sealift capability between the U.S. East and West Coasts. However, the time-sensitive nature of the rapid deployment mission tends to nullify this advantage and instead favors the development and maintenance of two-ocean sealift capability. For example, in the case of the Marine Corps, it is a decided advantage to have dedicated sealift available to support deployment of Marine Amphibious Forces from both Atlantic and Pacific coasts.

During time of crisis or national emergency, the entire U.S. commercial transporation system provides capability to support defense logistics requirements. Transportation routes and modes which serve normal commercial needs can be expected to provide priority service for national defense passengers and cargoes during national emergencies. If a Panama Canal is available it will be used to the extent that such use makes practical sense. On the other hand, since all other alternative transport routes and modes are also available, defense needs will be serviced by an optimal mix based on considerations of speed, capacity, safety, risk, etc.

Comparative Evaluation of Alternatives

The panelists felt the discussion of transportation alternatives should be limited to those alternatives over which the government has control, since the Conference was convened to aid the U.S. government in gaining information on transportation options as part of the feasibility study required by the Treaty. Thus, options that would be financed by the private sector would not fall within this category. (These would include pipelines, landbridges, and overland conveyors.) The categories that were felt to be appropriate for discussion were the two Panama Canal Commission options: (1) a $200 million expansion of the Gaillard Cut to 600 feet without new alignments, (2) a $500 million alternative that would increase the Gaillard Cut to 800 feet and would change all the alignments and approaches to the lock; the Lopez-Moreno plan which would cost $3.9 billion without interest costs; and the sea-level canal plan. Table 1 summarizes the various alternatives considered in terms of several evaluative criteria.

Financing

A key consideration of all transportation alternatives relates to funding. The group listed the funding mechanisms available for each plan.

Table 1

TRANSPORTATION ALTERNATIVE EVALUATION MATRIX
(For Potential U.S. Government-Involved Projects)

TRANSPORTATION ALTERNATIVE / EVALUATION CRITERIA	COST	FINANCING	TIME REQUIRED	TECHNOLOGICAL CONSTRAINTS	ENVIRONMENTAL CONSTRAINTS	DEFENSE CONSIDERATIONS	APPROPRIATENESS OF CONTRIBUTION TO CAPACITY	BENEFITS	DEGREE OF MULTILATERALISM
PANAMA CANAL WIDENING GAILLARD CUT TO 600 FEET 800 FEET	$200m 500m	•Will be a problem; capital cannot be borrowed or earned through tolls •Possibility of changing U.S. law •Panama cannot provide guarantees	•Short lead and construction time	•Research on canal size required for two-way traffic of largest ship that can transit canal	•Excavation and spoil disposal •Dredging effects on water	•Not a factor; same as present Panama Canal	•Increase capacity to 50 ships/day ≈ 17,500 ship transit; will be viable into early next century	•Increase capacity to 50 ships/day	•U.S. and Panama
LOPEZ-MORENO PLAN	$3.9b without interest; $7-8b including interest	•Problem in financing need for loan guarantees from user countries •Can be built in stages to lower costs •Possible regional development bank participation	•5 years	•Require 15 times as much water as present system •Lower level of lake •Construct locks	•Modification of Gatun Lake ecosystem •Dredging effects on water quality •Flooding •Excavation and spoil disposal	•Could not accommodate U.S. aircraft carriers	•Increase capacity to 40,000/year •Demand unlikely to reach that level using current projections	•Allow larger ships •Increase number of transits •Phase construction to meet demand •Lock size to meet market demand	•Consortium of user countries for financing •Possible regional development banks or World Bank participation
SEA-LEVEL CANAL	$15-20b including interest	•Similar financing; problems as Lopez-Moreno, only a more expensive project •U.S. defense support is doubtful	•15 years	•Construction of tidal gates •Large excavation	•Excavation and spoil disposal (effects on land use, water quality) •Loss of habitat, displacement of wildlife •Effects of interoceanic mixing on water quality •Mixing of biota	•Capable of handling U.S. aircraft carriers •Easier to repair in case of attack	•Substantially increase capacity •Demand unlikely to reach level using current projections	•Allow larger ships, including U.S. aircraft carriers •Increase number of transits	•Same as Lopez-Moreno •Possible U.S. Defense Department participation

1. Panama Canal Commission Plans. The Panama Canal Commission, by law, is not able to borrow money. Legislation for the Panama Canal stipulates that improvements are not to be a further tax burden to U.S. taxpayers. As a result, the only way they can generate funds to pay for modifications is to increase tolls. The Panama Canal currently operates on a break-even basis, with tolls reflecting only the costs of the Panama Canal Commission for labor, material, and minor capital improvements. Although the Treaty does not exclude the United States from guaranteeing financing for any new project, apparently the law would. It was pointed out, however, that the law can be changed and that this should not be a major consideration in the Conference deliberations.

The group felt a distinction should be made between economic viability and the feasibility of financing a project. The distinction is that economic viability relates to the need for a new or improved canal and to the level of tolls needed to pay the cost for these changes. Financing feasibility relates to the problem of who is going to underwrite any improvements or changes until a cash flow from the tolls begins.

2. Other Financing Options

Country guarantees of loans. Panama would not be capable of guaranteeing a loan because of its large public-sector debt. However, a country with a stronger economy or access to private capital markets, such as the U.S. or a consortium of countries, might be available to guarantee a loan. It was stated that there have been a few examples of countries getting together to guarantee the financing of projects that require large capital outlays, with the financially strongest countries guaranteeing the loan. Possible countries to be included in such an option would be the United States, Japan, the Western European countries and certain Latin American countries.

The United States Government was not considered a probable source of funding because of the political difficulties involved in Congressional appropriation of funds for such a project. In addition, there are specific requirements for U.S. participation in financing a project. The government must know the exact cost of the project and which party would be responsible for carrying the burden of any mistake. The United States does not agree to finance projects on a percentage basis; it only finances projects with a specific dollar amount requested.

Financing through development banks. For example, the Inter-American Development Bank or the World Bank may be interested in financing future canal projects. Although there was not a strong indication of support for regional development banks or World Bank financing, it was considered an option.

Guarantees by the larger users (private sector). The first task would be to identify the project and the major beneficiaries of the project. The next step would be to identify the amounts that can be financed by the users and where that financing would come from. However, there is a problem in identifying who benefits from improvements to the Panama Canal or the construction of a new canal and it is difficult to apportion the cost of that project to the beneficiaries.

The financing of the Lopez-Moreno plan demonstrates the difficulty of financing a major expansion of the existing Panama Canal facilities or a sea-level canal. The construction cost involved in the Lopez-Moreno plan is $3.9 billion, not including interest charges. If interest charges are included the total cost of the project is $7-$8 billion. While there may be a long-term trade benefit from the construction of an option such as the Lopez-Moreno plan, it is impossible to capture that benefit from the users through a toll system.

There are possibilities of funding these plans by external sources. For example, nations that use the Canal could contribute a nonrefundable portion and the balance could be recovered from the users. Otherwise, large capital projects could not be economically justified.

Cost-Benefit Analysis

Rough calculations were made to show capital costs in relation to the increase in capacity realized by various options.

	Option	Cost	Capacity Increase	Cost/Ton
1.	Pipeline	$200 m	50 m tons	$4 m/ton
2.	Widening of Gaillard Cut	$500 m	40 m tons	$12.5 m/ton
3.	Lopez-Moreno with interest costs	$8.0 b	250 m tons	$32 m/ton
4.	Sea-level canal with interest costs	$20 b	250 m tons	$80 m/ton

There was disagreement with the calculations presented. Some participants felt that with a major Canal project (Lopez-Moreno), there would be a significant increase in trade that utilizes the new scheme. The savings to users would justify increased tolls and hence make the project more attractive. It was pointed out, on the other hand, that any project requiring a significant capital outlay could only be justified by the anticipation of a "quantum" leap in trade. Some participants felt it was difficult to foresee a doubling or tripling of trade through the Isthmus over the next 30 years.

Areas of Government Concern

The participants identified several crucial areas that should be of interest to the U.S. government that should be considered in policy planning for the Panamanian Isthmus:

- Cost estimates: This was felt to be the most important factor. It is crucial to identify and be able to justify the need of each alternative, its exact cost and a means for dealing with cost overruns.

- Funding: The funding issue is closely related to the question of cost and was thought to be of the highest priority.

Funding sources must be identified and international cost sharing arrangements must be developed, if appropriate.

- Political understanding: It is important to identify the political constituencies that will be involved in any decisions.

- Political climate: It is important to have an understanding of the political climate of Panama in the year 2000 and beyond.

- Development of planning process: A decision on the transportation alternatives does not have to be made at this point. However, it is important to create a planning system that will enable the U.S. government to review the options at the appropriate times in order to make these decisions. If the government is without a planning system and allows itself to make piecemeal decisions on short payout items, it is predestined to make a choice that may not be appropriate. It is important to have a master plan to use consistently over time. It was also pointed out that the government should avoid preemptive decisions that could be postponed. It was felt that no decision has to be made in the immediate future with respect to some of the marginal projects that have been discussed. In addition, it was felt that the Panama Canal Commission would need accurate short-term traffic forecasts that would indicate when the Panama Canal Commission would have to initiate the first steps for transportation arrangements. It is also important to know what the first steps should be. This could be done with periodic updates to keep ahead of the lead time required for any projects.

  To this end, the Panama Canal Commission is preparing forecasts up to the year 2000 for commodities and is using a system-analysis approach to look at the widening project in order to determine the optimum cost of that program. The plan will be submitted to the Board of Directors of the Panama Canal Commission. The issue of where the money will come from will then be addressed.

- Need for new studies: There was concern that the report should identify issues that need to be studied and how those studies should be undertaken. Since the issues relating to transportation alternatives are complicated, it will require a more detailed discussion and study than the group was able to give. This effort will contribute to the Department of State's work on the terms of reference for the feasibility study.

- Environmental impacts for the sea-level canal as well as the third-lock options: Environmental impacts include both the mixing of the Atlantic and Pacific Ocean biota and the problems created by the loss of land for 23,000 people living in the area where the sea-level canal would be built.

Government Planning Horizon

The question was raised as to whether the United States should concern itself with what should be done to the Panama Canal beyond the year 2000. The role of the current Panama Canal Commission was viewed as being one of active management for the facility. This role would include the undertaking of planning studies and an evaluation of the means for implementing the studies' results. It was noted that the United States will continue to have an interest in how the Canal is used in serving U.S. needs and the needs of the world after the year 2000. The difference is that after 2000 the United States will have far less power to influence decisions. An important question in this regard is: Under what conditions would Congress approve an expenditure for facilities that the United States would not own or control unilaterally?

Recommendations for the Terms of Reference

The participants offered recommendations for U.S. government participants in the Preparatory Committee meeting. These include:

1. There should be a mapping of key benchmarks and lead times to allow for the pacing of decisions.

2. Commodity forecasts should be made for the period beyond the year 2000, taking into account the transfer of ownership of the Canal to Panama.

3. Future trading opportunities should be investigated in order to assess whether the expenditure of large amounts of money on new projects can be justified on the basis of the benefits derived.

4. There was disagreement among the participants as to whether defense considerations should be included in the terms of reference.

5. A more complete investigation of the financing options available for any improvement or modification is required.

6. There is a need to develop updated cost estimates for all options.

7. It will be important to establish information on the ship mix and transit times for ships that use the Canal.

8. An assessment of the operating rules and philosophy of the Panama Canal Commission (e.g., break-even toll structure) should be renewed.

9. Any project requiring U.S.-appropriated funds should carefully assess the environmental impact of that project.

10. An entire project overview must be made, and it should define where more detailed analysis is needed.

11. The main issue is the transit capacity of the Isthmus. Therefore, the subject of investigation should be whether a larger Canal is needed, not whether a sea-level canal is needed.

12. There is a need for a better understanding of the precise economic consequences that might result from a surge in worldwide economic activity, such as occurred in the 1960s, and a concurrent increase in Panama Canal traffic. The key question is how much will traffic decline after an adjustment to alternatives is made. If the Panama Canal loses more traffic than simply the excess margin, then proposed canal improvements are worth more than the difference between present and future capacity.

13. One suggested approach for the feasibility study is to do a number of scenarios that would take into account three or four different options, assume their viability and existence, and work back from those scenarios to determine cost implications, financing options, impacts on various interested parties (governments, local populations, commodity producers, shippers, Canal authorities, etc.), extent of need given likely future trade flows, and timing.

III. CONFERENCE PARTICIPANTS BRIEFING BOOK

BRIEFING BOOK

for the Conference on

FUTURE TRANS-PANAMANIAN TRANSPORTATION ALTERNATIVES

Prepared for the

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October 13-14, 1982

INTRODUCTION

This briefing book contains background information on two vital areas of discussion at the Conference--forecasts of commodity shipments through the Panama Canal to the year 2010 and the related number of ship transits, and essays on transportation alternatives to the Panama Canal. The information is intended as rudimentary data on the subjects and is not to be construed as definitive conclusions for the Conference. Instead, this material should be used by the participants to help them structure and prepare their comments for the Conference.

The Futures Group's goal is to provide the Department of State and other government agencies with information on alternatives for trans-Isthmian transportation that will be useful in the development of U.S. policy. The Conference is one vehicle chosen to provide this data. The Futures Group does not hold any fixed views on the outcome of the Conference, but rather, is concerned with the exposition of all relevant material. The absence of any material in this book should not be interpreted as a deliberate omission or an inappropriate subject for discussion. All subjects that the participants consider relevant may be discussed at the Conference.

FORECASTS OF PANAMA CANAL SHIPMENTS

Introduction

The forecasts of the eleven commodity groups in this book make use of Trend Impact Analysis (TIA). TIA is an analytic procedure, developed by The Futures Group, that divides the tasks of forecasting so that the analysts and the computers are assigned precisely the task that each does best. First, the computer extrapolates the past history of the trend. Then the analyst specifies a set of future events along with estimates of the events' impact on the trend and their probability of occurrence. The computer combines these judgments mathematically to modify the trend extrapolation. The analyst then evaluates the adjusted extrapolation and modifies the input data in those cases where the output appears unreasonable.

The Futures Group has produced forecasts, based on its preliminary judgments of the input information (future events, probabilities of occurrence and the timing and magnitude of the impacts). The participants will be responsible for assessing whether the input data and forecasts are reasonable and for suggesting additional events or alternative inputs or probabilities. The ultimate aim of this exercise is to develop an estimate of the level of total shipments through the Panama Canal during the forecast period. This estimate, in turn, will be used to determine if total shipments will exceed the canal's capacity.

An annotated sample TIA of Brazil's Gross Domestic Product (GDP) is included as an illustration of the forecasting technique. It is important to note that the Table of Events (Figure 1) is arranged in order, with events having the most negative impact at the top and events having the most positive influence at the bottom. The study team is using the center forecast as the most likely projection for each commodity.

Historical Data

Extrapolation of Historical Data without Any Perturbing Future Events

Low Range of Expectation with the Perturbing Events

Mean Range of Expectation with the Perturbing Events

High Range of Expectation with the Perturbing Events

BRAZIL GDP ($1979 BILLION)

TREND IMPACT ANALYSIS

BASELINE CURVE NO. = 1 CONFIDENCE PERCENTILES = 25 AND 75

		***	FORECAST	***
YEAR	HISTORY/ BASELINE	LOWER	CENTER	UPPER
1963	52.65			
1964	54.18			
1965	66.74			
1966	69.26			
1967	72.63			
1968	80.75			
1969	88.77			
1970	96.58			
1971	109.44			
1972	122.28			
1973	139.28			
1974	152.90			
1975	161.60			
1976	176.10			
1977	184.31			
1978	195.41			
1979	207.90			
1981	227.84	204.48	219.85	227.54
1982	238.68	206.06	225.61	234.97
1983	249.51	209.67	232.03	242.88
1984	260.35	215.14	239.50	251.74
1985	271.19	221.73	247.84	261.45
1986	282.03	230.24	257.68	272.67
1987	292.87	241.84	269.19	285.53
1988	303.70	251.58	279.96	297.81
1989	314.54	260.84	290.52	310.07
1990	325.38	269.66	300.83	322.14

Figure 1. Typical TIA Forecast

Cumulative Probability of Event Occurrence by Year

Time from Occurrence of Event Until the Trend Begins To Respond

Time from Occurrence Until the Impact on the Trend Is the Largest

Magnitude of Largest Impact

Magnitude of Steady-State Level

Index Number of the Magnitude of the Impact Over the Forecast Period (0=No Impact)

Time from Occurrence Until the Impact Reaches a Final or Steady-State Level

List of Perturbing Events in Order from Most Negative (Top) to Most Positive (Bottom)

BRAZIL GDP ($1979 BILLION)

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
1	1985 0.50 1990 0.70 -106. SUPPLY DISRUPTION IN MIDEAST; OIL PRICES RISE FASTER THAN INFLATION IN OECD	0	1	-10.0%	5	-7.0%
2	1985 0.40 1990 0.60 -74.2 ONSET OF PROTECTIONISM AS A NATIONAL GOAL IN THE INDUSTRIALIZED COUNTRIES AGAINST LDC MANUFACTURED GOODS (TEXTILES,SHOES,ETC)	0	2	-10.0%	4	-6.0%
3	1985 0.35 1990 0.60 -62.9 WORLD ECONOMIC SLOWDOWN RESULTS IN REDUCED DEMAND FOR BRAZILIAN GOODS	0	2	-15.0%	5	0. %
4	1985 0.20 1995 0.35 -26.3 LABOR UNIONS STRIKE; CAUSE ENTIRE COUNTRY TO SHUT DOWN	0	1	-25.0%	2	0. %
5	1985 0.10 1990 0.30 -19.9 LEFTIST GAIN POWER IN BRAZIL	0	1	-8.0%	5	-2.0%
6	1985 0.20 1990 0.40 -18.1 BUSINESS CLIMATE IN BRAZIL FOR MULTINATIONAL PARTICIPATION SOURS (THREAT OF EXPROPRIATION,REPATRIATION, RESTRICTIONS,ETC.)	1	3	-5.0%	8	-2.0%
7	1985 0.20 1990 0.40 28.0 SIGNIFICANT TARIFF REDUCTIONS AND EXPANSION OF COVERAGE OF GSP (GENERALIZED SYSTEM OF PREFERENCES) RESULTS IN OPEN MARKET FOR LDC MANUFACTURED GOODS IN DEVELOPED COUNTRIES	0	2	5.0%	2	5.0%
8	1985 0.10 1990 0.25 28.3 GOVERNMENT REMOVES ALL CONTROLS ON FOREIGN INVESTMENT	0	3	10.0%	3	10.0%
9	1985 0.25 1990 0.50 45.8 OPEC ADOPTS A MODERATE PRICING POLICY TOWARDS NON-OIL LDCS	0	1	8.0%	3	5.0%

Figure 1 (Cont.)

BRAZIL GDP ($1979 BILLION)

HISTORICAL DATA = O
CALCULATED DATA = X
TIA FORECAST = *
BASELINE CURVE NO. = 1
CONFIDENCE PERCENTILES = 25 AND 75

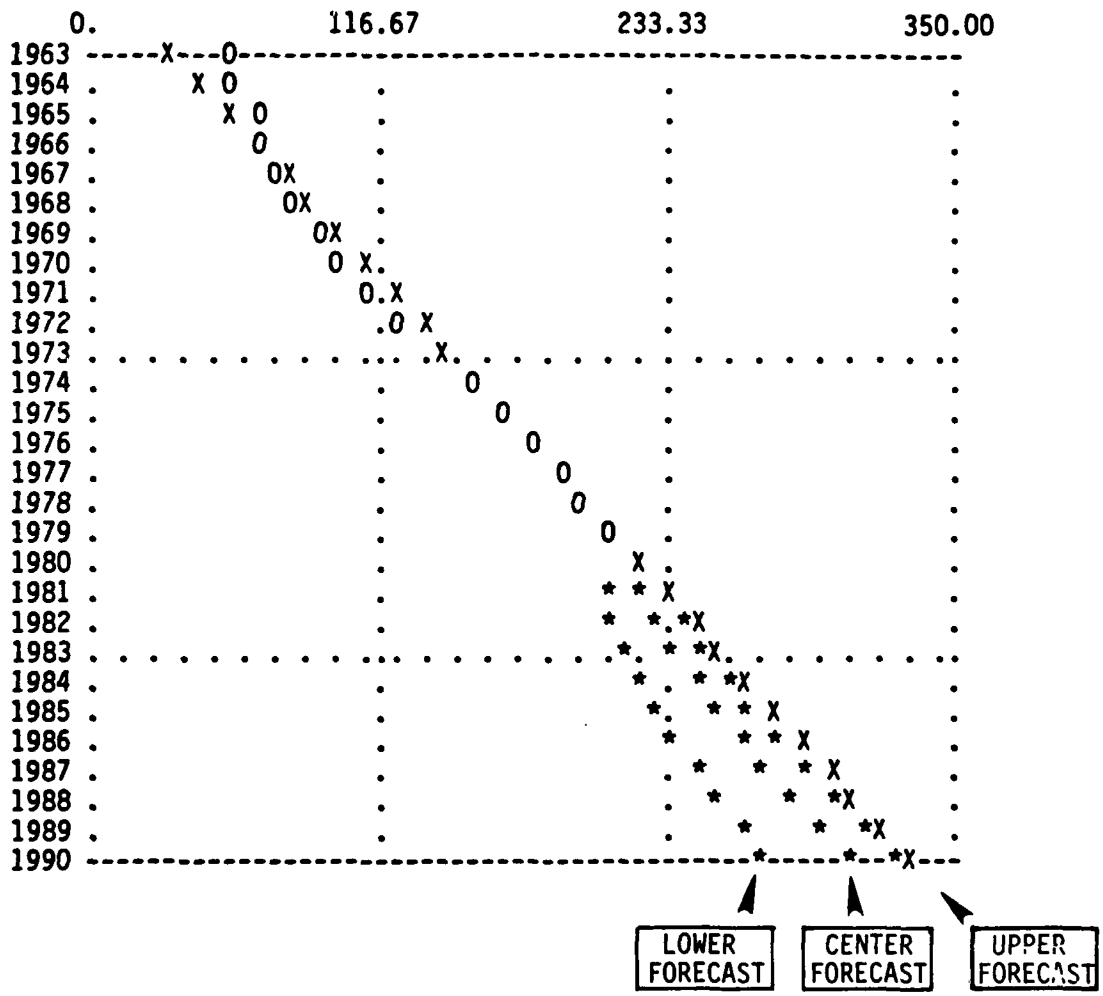


Figure 1 (Cont.)

COMMODITY PROJECTIONS

The following forecasts of future shipments through the Panama Canal are based on traffic statistics developed and maintained by the Panama Canal Commission. Historically, the Commission has divided its data on shipments into 23 separate categories. To reduce the number of individual forecasts, the study team, with the assitance of Ely Brandes, has rearranged the data and collapsed the Panama Canal Commission's data into 11 larger categories. However, it is important to recognize that this has not changed the data on total shipments.

The table on page 77 gives projected total commodity shipments through the Panama Canal by 2010, using the center (median) projection. The upper and lower limits of the forecasts are included to indicate the range of uncertainty for each commodity.

SHIPMENTS OF GRAINS AND SOYBEANS
(Thousands of Tons)

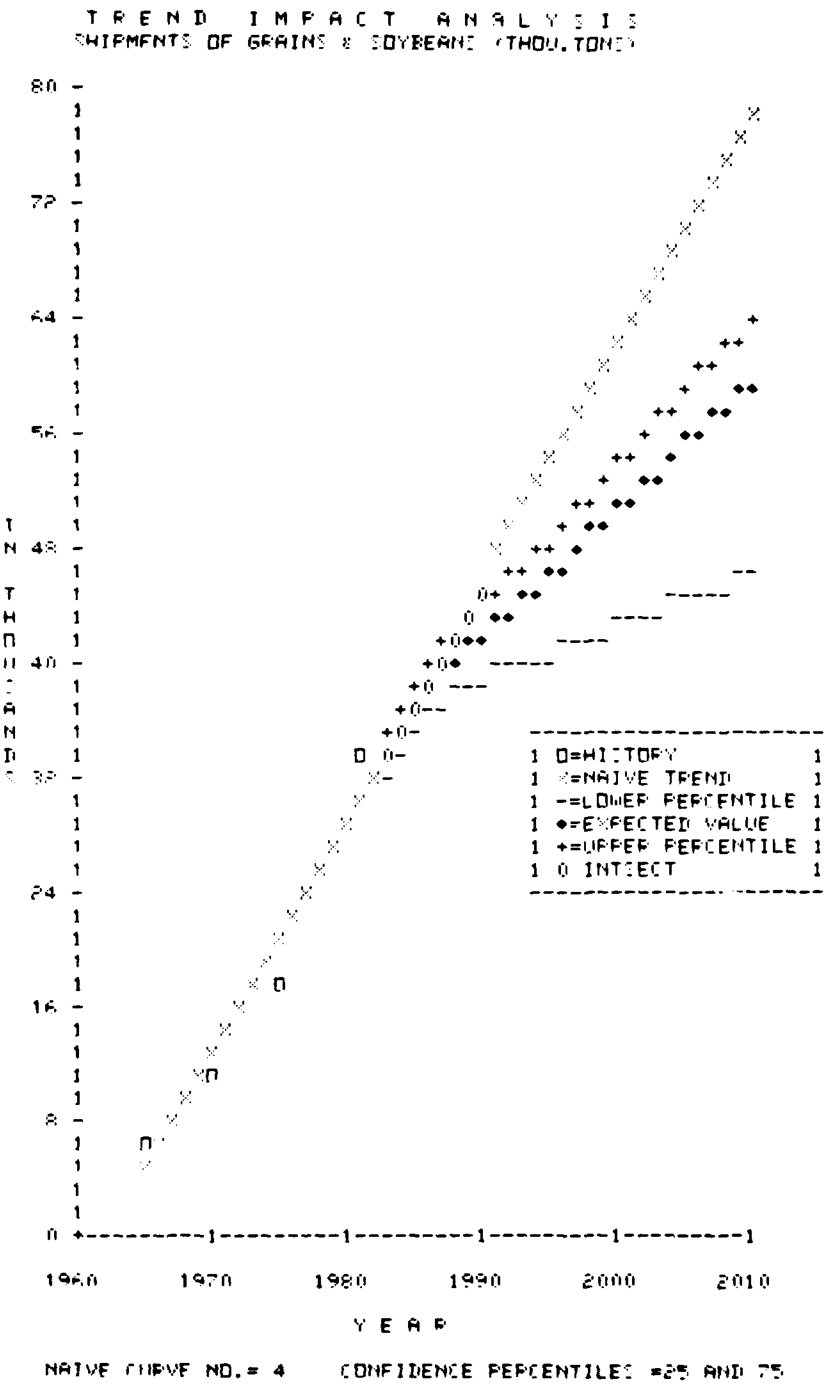
TREND IMPACT ANALYSIS

BASELINE CURVE NO. = 4 CONFIDENCE PERCENTILES = 25 AND 75

		***	FORECAST	***
YEAR	HISTORY/ BASELINE	LOWER	CENTER	UPPER
1965	6916.00			
1970	11399.00			
1975	17170.00			
1981	33693.00			
1983	34132.23	32012.05	33893.49	35743.20
1984	35768.89	33405.87	35325.42	37180.74
1985	37404.71	34739.61	36714.05	38575.85
1986	39039.71	36005.20	38055.11	39925.76
1987	40673.88	37112.52	39377.96	41161.43
1988	42307.24	38015.56	40371.15	42274.02
1989	43939.77	38673.44	41323.25	43255.21
1990	45571.49	39056.45	42122.81	44097.11
1991	47202.39	39384.73	42939.83	44963.38
1992	48832.45	39661.60	43781.71	45861.47
1993	50461.71	39941.72	44611.80	46756.86
1994	52090.15	40223.06	45433.21	47653.38
1995	53717.77	40505.97	46249.03	48554.78
1996	55344.58	40820.95	47089.70	49491.67
1997	56970.57	41175.71	47960.73	50469.25
1998	58595.75	41590.37	48876.49	51501.19
1999	60220.11	42074.32	49943.21	52593.21
2000	61843.66	42519.00	50780.39	53674.57
2001	63466.40	42931.30	51692.36	54748.69
2002	65088.33	43332.80	52597.69	55832.13
2003	66709.45	43713.04	53486.43	56900.06
2004	68329.76	44072.68	54358.95	57952.34
2005	69949.27	44412.43	55215.62	58998.83
2006	71567.96	44746.64	56070.14	60022.86
2007	73185.85	45071.98	56919.33	61051.18
2008	74802.93	45390.29	57764.18	62074.52
2009	76419.21	45703.47	58605.66	63093.60
2010	78034.68	45994.64	59430.86	64095.41

SHIPMENTS OF GRAINS & SOYBEANS (THOU.TONS)

EVENT NO.	YEAR PROB / RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
8	1990 0.20	5	10	-25.0%	10	-25.0%
	2000 0.40					
	2010 0.60					
-0.869E+05	SUCCESS OF CHINA'S AGRICULTURAL POLICY INCREASES FAR EASTERN PRODUCTION OF GRAIN.					
4	1990 0.80	0	8	-7.0%	10	-5.0%
	2000 0.90					
	2010 0.90					
-0.604E+05	EXPANSION OF GRAIN SHIPMENTS FROM WEST COAST US					
6	1990 0.99	0	1	-3.0%	1	-3.0%
	2000 0.99					
	2010 0.99					
-0.423E+05	US GRAIN EXPORTS WILL GROW AT AN ANNUAL AVERAGE RATE OF 4% AFTER 1985 (AVERAGE ANNUAL GROWTH FROM 1970-80 WAS 11%)					
3	1990 0.50	5	10	-5.0%	10	-5.0%
	2000 0.80					
	2010 0.80					
-0.366E+05	SHIFT IN FAR-EAST GRAIN TRADE PATTERNS AWAY FROM US SUPPLIERS (E.G., GREATER IMPORTS FROM S.AFRICA, AUSTRALIA, ARGENTINA)					
5	1990 0.30	5	10	-5.0%	10	-5.0%
	2000 0.40					
	2010 0.50					
-0.199E+05	INCREASING % OF EAST-WEST GRAIN SHIPMENTS VIA CAPE HORN (EG.G. GREATER USE OF LARGE BULK CARRIERS)					
1	1990 0.30	5	15	-5.0%	15	-5.0%
	2000 0.50					
	2010 0.95					
-0.194E+05	PANAMA CANAL TOLL INCREASE OF GREATER THAN 25%					
2	1990 0.30	5	20	9.0%	20	8.0%
	2000 0.50					
	2010 0.80					
0.251E+05	CHANGES IN DIETARY PATTERNS IN THE FAR-EAST CAUSE AN INCREASE IN GRAIN DEMAND					


TREND IMPACT ANALYSIS
SHIPMENTS OF GRAINS & SOYBEANS (THOU.TONS)
80
72
64
56
48
40
32
24
16
8
0
IN THOUSANDS
1960
1970
1980
1990
2000
2010
YEAR
O=HISTORY
X=NAIVE TREND
-=LOWER PERCENTILE
◆=EXPECTED VALUE
+=UPPER PERCENTILE
0 INTSECT
NAIVE CURVE NO.= 4
CONFIDENCE PERCENTILES =25 AND 75

SHIPMENTS OF PETROLEUM AND PETROLEUM PRODUCTS (Thousands of Tons)

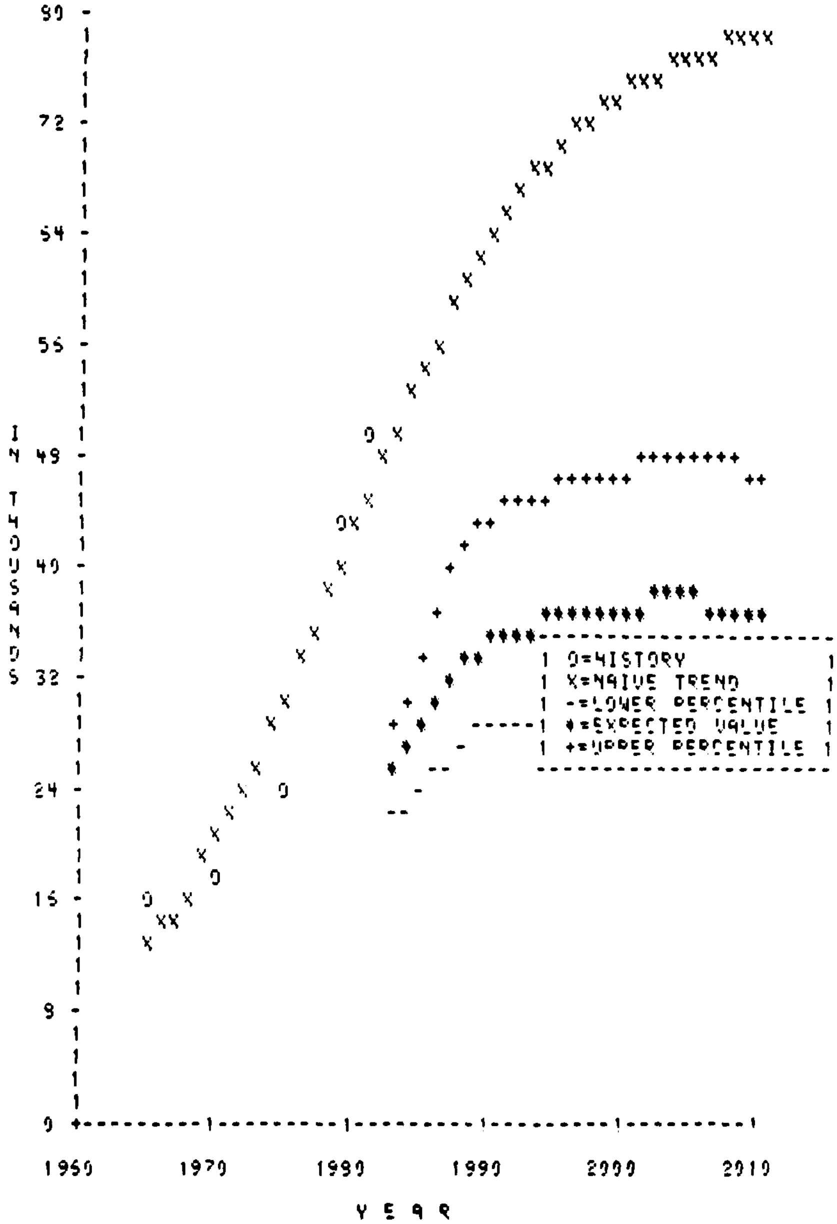
TREND IMPACT ANALYSIS

BASELINE CURVE NO. = 14   CONFIDENCE PERCENTILES = 25 AND 75

		***	FORECAST	***
YEAR	HISTORY/ BASELINE	LOWER	CENTER	UPPER
1965	15299.00			
1970	17665.00			
1975	23905.00			
1979	42857.00			
1981	49329.00			
1983	50215.44	21882.58	25256.51	29160.68
1984	52482.36	22187.18	25616.69	31003.81
1985	54663.78	23458.04	28253.66	33494.13
1986	56749.90	24873.79	29976.86	35404.74
1987	58729.18	26394.11	31771.00	39766.44
1988	60599.47	27524.85	33140.20	41715.30
1989	62352.84	28200.93	34042.04	42837.91
1990	63990.49	28787.95	34857.63	43860.08
1991	65511.49	29127.61	35446.43	44628.29
1992	66917.51	29105.02	35727.65	45023.89
1993	68211.64	28935.70	35933.11	45338.96
1994	69399.04	28797.62	36115.10	45572.33
1995	70481.70	28697.94	36301.76	45788.99
1996	71465.21	28643.26	36509.59	45968.68
1997	72363.56	28553.22	36697.02	46222.01
1998	73173.91	28476.61	36591.63	46514.37
1999	73905.52	28374.30	37050.93	46762.03
2000	74564.54	28250.73	37178.94	46969.68
2001	75156.97	28278.80	37410.98	47265.87
2002	75688.56	28539.10	37753.43	47642.31
2003	76164.78	28643.93	37805.43	47746.11
2004	76590.77	28577.54	37787.68	47783.76
2005	76971.32	28378.23	37696.71	47744.86
2006	77310.89	28050.16	37516.87	47613.62
2007	77613.56	27686.56	37298.61	47439.68
2008	77883.10	27288.28	37044.04	47225.65
2009	78122.94	26856.02	36755.07	46973.92
2010	78336.18	26390.38	36433.44	46696.66

```
SHIPMENTS OF PETROLEUM & PETRO. PRODUCTS (THOU. TONS)


EVENT  YEAR/PROB  YRS TO  YRS TO   MAXIMUM  YRS TO   STEADY
 NO.              FIRST   MAXIMUM  IMPACT   STEADY   STATE
   RELATIVE       IMPACT  IMPACT            STATE    IMPACT
   IMPACT                                   IMPACT

     8  1990 0.99    0       1       -50.0%   15      -40.0%
        2000 0.99
        2010 0.99
 -0.741E+06
        TRANS-PANAMANIAN PIPELINE IS OPERATIONAL

     2  1990 0.15    0       2       -25.0%    5      -10.0%
        2000 0.40
        2010 0.50
 -0.716E+05
        CONSTRUCTION OF NORTHERN TIER PIPELINE

     4  1990 0.50    0       2        -5.0%    2       -5.0%
        2000 0.80
        2010 0.95
 -0.619E+05
        MAJOR OIL COMPANIES SIGN PRODUCT EXCHANGE AGREEMENTS FOR
        CRUDE OIL AND REFINED PRODUCT

     7  1990 0.30    0       1       -10.0%    3       -5.0%
        2000 0.70
        2010 0.95
 -0.600E+05
        TRANS-GUATEMALAN PIPELINE IS OPERATIONAL

     5  1990 0.30    5      15       -10.0%   15      -10.0%
        2000 0.50
        2010 0.95
 -0.437E+05
        PANAMA CANAL TOLL INCREASE OF MORE THAN 25%

     1  1990 0.35    1       3        10.0%    5        0. %
        2000 0.50
        2010 0.65
  0.102E+05
        NEW FINDS IN ALASKA AND OFF-SHORE CALIFORNIA ARE BROUGHT ON
        STREAM AND INCREASE PRODUCTION TO 700,000 B/D

     6  1990 0.50    0       1        10.0%    3        0. %
        2000 0.75
        2010 0.90
  0.115E+05
        MAJOR OIL SUPPLY DISRUPTION (E.G.,OPEC EMBARGO,MID-EAST
        CONFLICT)

     3  1990 0.25    1       5        50.0%    7        3.0%
        2000 0.50
        2010 0.75
  0.964E+05
        NEW NON-U.S. OIL FIND(E.G.,OFF-SHORE GUATEMALA)
```

TREND IMPACT ANALYSIS
SHIPMENTS OF PETROLEUM & PETRO. PRODUCTS (THOU. TONS)



NAIVE CURVE NO.=14   CONFIDENCE PERCENTILES =25 AND 75

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SHIPMENTS OF COAL
(Thousands of Tons)

TREND IMPACT ANALYSIS

BASELINE CURVE NO. = 1 CONFIDENCE PERCENTILES = 25 AND 75

YEAR	HISTORY-BASELINE	*** LOWER	FORECAST CENTER	*** UPPER
1965	6696.00			
1970	21332.00			
1975	26303.00			
1979	13892.00			
1981	20210.00			
1983	22481.76	18699.14	22729.89	26831.56
1984	23014.56	19291.12	23338.41	27489.72
1985	23547.36	19781.54	23863.75	28052.89
1986	24080.15	20223.68	24344.65	28560.96
1987	24612.95	20630.52	24795.61	29035.78
1988	25145.75	21032.65	25249.78	29530.26
1989	25678.54	21428.34	25707.59	30056.58
1990	26211.34	21815.76	26169.51	30627.59
1991	26744.14	22163.33	26600.78	31212.45
1992	27276.93	22492.09	27020.54	31924.96
1993	27809.73	22960.14	27488.47	32568.32
1994	28342.52	23272.57	28007.58	33449.53
1995	28875.32	23697.28	28556.29	34448.71
1996	29408.12	24137.66	29139.53	35568.77
1997	29940.91	24575.50	29739.97	36786.31
1998	30473.71	24955.00	30281.73	37782.20
1999	31006.51	25272.41	30761.56	38592.15
2000	31539.30	25529.15	31179.75	39244.63
2001	32072.10	25635.71	31446.69	39664.62
2002	32604.90	25598.04	31566.98	39859.78
2003	33137.69	25589.89	31716.58	40088.37
2004	33670.49	25615.94	31897.58	40349.72
2005	34203.29	25662.06	32099.46	40630.54
2006	34736.08	25736.62	32330.00	40936.77
2007	35268.88	25821.64	32571.93	41273.95
2008	35801.68	25918.01	32826.12	41644.04
2009	36334.47	26026.60	33093.45	42046.86
2010	36867.27	26140.69	33369.57	42484.91

SHIPMENTS OF COAL (THOU TONS)

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
4	1990 0.50 2000 0.80 2010 0.99	1	3	-10.0%	5	-10.0%

-0.515E+05
SIGNIFICANTS INCREASE IN COAL EXPORTS FROM FOREIGN COAL SUPPLIERS (E.G., AUSTRALIA, S.AFRICA)

3	1990 0.30 2000 0.50 2010 0.90	5	15	-15.0%	15	-15.0%

-0.288E+05
PANAMA CANAL TOLL INCREASE OF GREATER THAN 25%

5	1990 0.20 2000 0.50 2010 0.70	2	8	-10.0%	8	-10.0%

-0.246E+05
SHARP RISE IN USE OF SUPER-COLLIERS ON BY-PASS ROUTES

1	1990 0.10 2000 0.30 2010 0.50	1	15	-15.0%	20	-10.0%

-0.159E+05
US WEST COAST INFRASTRUCTURAL IMPROVEMENTS CAUSE SHIFT IN ASIAN COAL DEMAND FROM EAST COAST TO WEST COAST SUPPLIERS (EG, PORTS, RAILROADS, SLURRY PIPELINES)

8	1990 0.05 2000 0.20 2010 0.30	5	15	5.0%	20	2.0%

0.234E+04
THE RISE OF A RAPIDLY INDUSTRIALIZING ECONOMY IN THE FAR-EAST (E.G., ALONG THE LINES OF JAPAN IN 1950-70)

6	1990 0.10 2000 0.40 2010 0.40	0	1	3.0%	1	3.0%

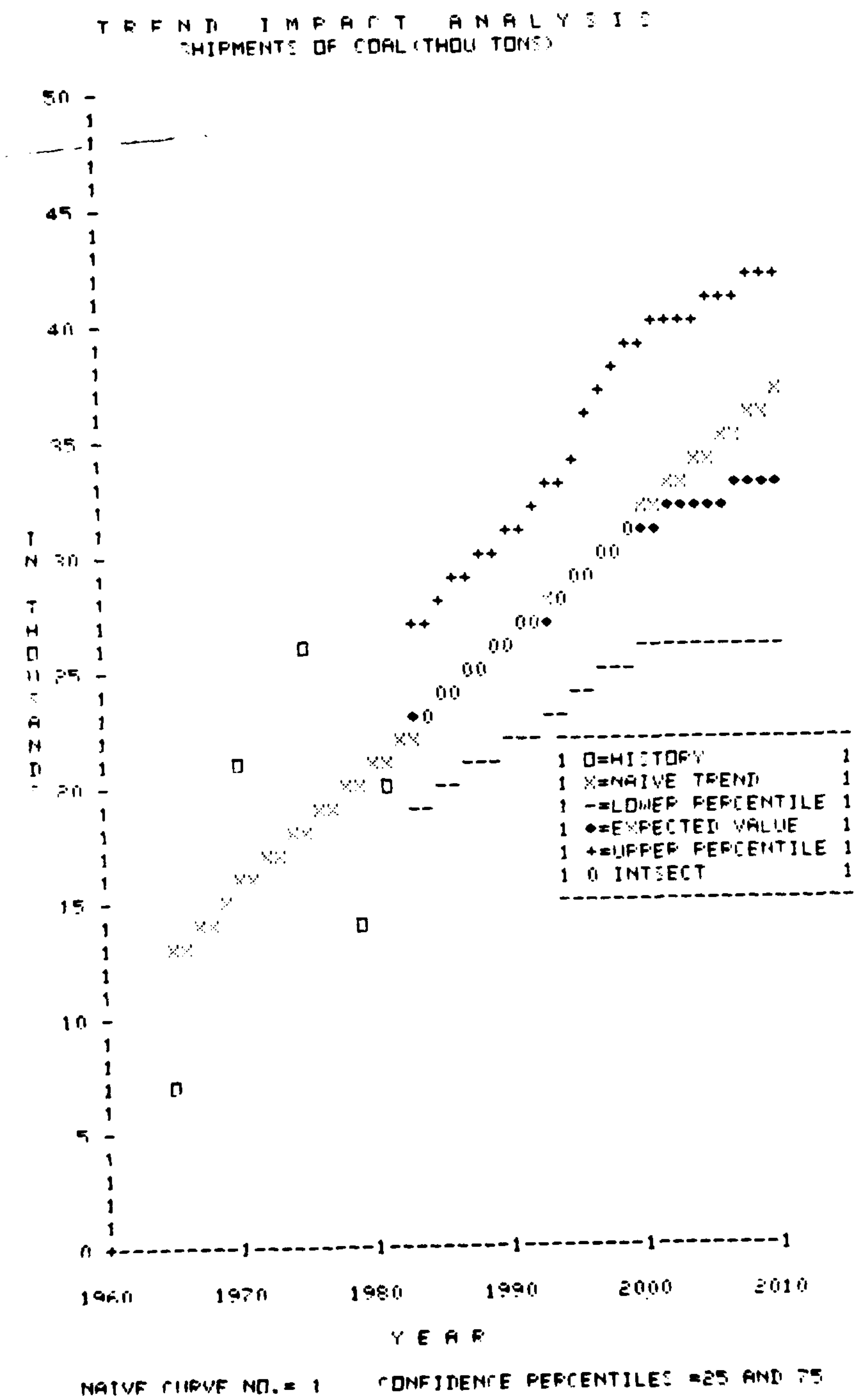
0.670E+04
LARGE INCREASE IN BACK HAUL TRADE THROUGH THE CANAL (E.G., INCREASE IN CARGO SHIPMENTS THAT CAN USE COAL AS A BACK HAUL COMMODITY)

7	1990 0.50 2000 0.80 2010 0.80	0	1	15.0%	5	5.0%

0.326E+05
SUPPLY DISRUPTIONS FROM AUSTRALIA, SOUTH AFRICA, OR CHINA.

2	1990 0.15 2000 0.30 2010 0.50	5	15	75.0%	20	15.0%

0.561E+05
LONG-TERM DISRUPTIONS IN OIL AND/OR NUCLEAR FUEL SUPPLIES (E.G., PRODUCTION REDUCTIONS OR PLANT SHUT-DOWNS) LEAD TO RAPID INCREASE IN WORLD DEMAND FOR STEAM COAL


TREND IMPACT ANALYSIS
SHIPMENTS OF COAL (THOU TONS)
IN THOUSAND
50
45
40
35
30
25
20
15
10
5
0
1960
1970
1980
1990
2000
2010
YEAR
1 O=HISTORY 1
1 X=NAIVE TREND 1
1 -=LOWER PERCENTILE 1
1 *=EXPECTED VALUE 1
1 +=UPPER PERCENTILE 1
1 0 INTSECT 1
NAIVE CURVE NO.= 1 CONFIDENCE PERCENTILES =25 AND 75

SHIPMENTS OF ORES
(Thousands of Tons)

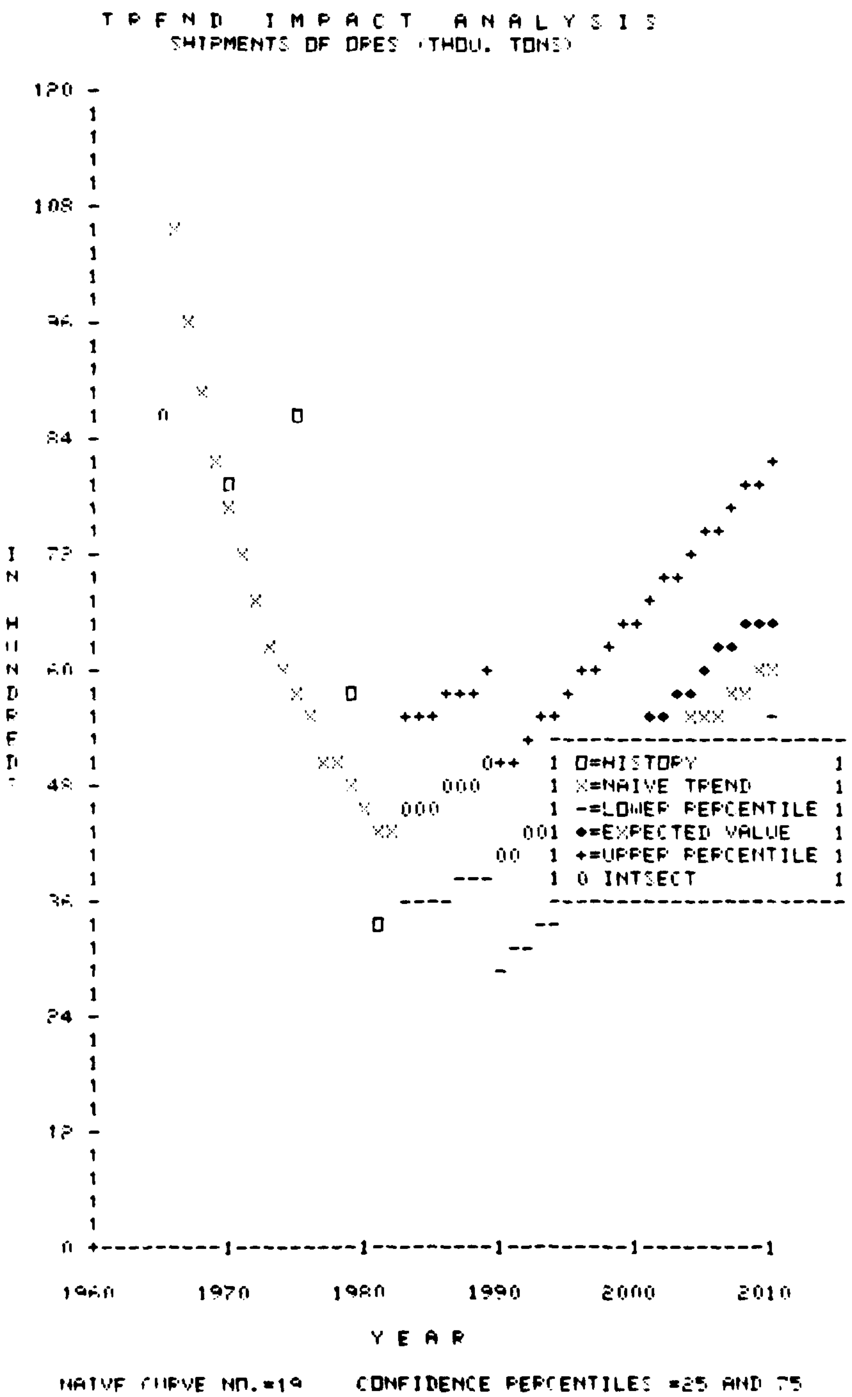
TREND IMPACT ANALYSIS

BASELINE CURVE NO. = 19   CONFIDENCE PERCENTILES = 25 AND 75

YEAR	HISTORY-BASELINE	*** LOWER	FORECAST CENTER	*** UPPER
1965	8611.00			
1970	7947.00			
1975	8650.00			
1979	5969.00			
1981	7273.00			
1983	4509.63	3485.76	4494.60	5502.35
1984	4589.56	3548.24	4559.26	5567.10
1985	4670.08	3603.13	4618.19	5626.22
1986	4750.30	3664.10	4681.69	5689.84
1987	4830.53	3737.54	4756.90	5766.02
1988	4910.75	3816.51	4838.99	5851.93
1989	4990.97	3900.40	4928.30	5950.05
1990	4000.00	2943.77	3967.74	4994.23
1991	4100.00	3067.47	4095.78	5138.97
1992	4200.00	3202.74	4235.92	5304.11
1993	4300.00	3338.54	4376.57	5469.55
1994	4400.00	3474.86	4517.65	5635.09
1995	4500.00	3610.33	4658.06	5799.60
1996	4600.00	3741.33	4794.13	5959.16
1997	4700.00	3868.06	4926.00	6113.44
1998	4800.00	3992.70	5055.98	6265.96
1999	4900.00	4115.93	5184.49	6416.66
2000	5000.00	4237.69	5311.38	6564.88
2001	5100.00	4360.70	5439.17	6712.60
2002	5200.00	4499.07	5572.04	6866.68
2003	5300.00	4622.59	5709.61	7026.72
2004	5400.00	4761.81	5852.09	7192.92
2005	5500.00	4899.24	5993.90	7359.80
2006	5600.00	5026.56	6126.59	7518.40
2007	5700.00	5145.97	6251.70	7668.67
2008	5800.00	5256.87	6368.81	7809.10
2009	5900.00	5360.78	6478.79	7939.35
2010	6000.00	5457.41	6581.28	8057.75

SHIPMENTS OF ORES (THOU. TONS)

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
2	1990 0.40 2000 0.80 2010 0.99 -0.474E+04	0	3	-10.0%	5	-5.0%
	U.S. AND CANADIAN SMELTERS SIGN PRODUCT EXCHANGE AGREEMENTS FOR AUSTRALIAN AND CARIBBEAN PRODUCED BAUXITE					
6	1990 0.20 2000 0.45 2010 0.75 -0.301E+04	5	7	-12.0%	20	-5.0%
	SOUTH AMERICAN ORE PRODUCERS EXPAND SMELTING OF ORES AS PART OF ECONOMIC DEVELOPMENT PROGRAM					
4	1990 0.30 2000 0.50 2010 0.95 0.	5	15	-10.0%	3	0. %
	PANAMA CANAL TOLL INCREASE OF MORE THAN 25%					
3	1990 0.50 2000 0.90 2010 0.99 0.139E+05	5	10	25.0%	15	20.0%
	LARGE DISCOVERIES OF ORES IN AMAZON REGION OF NORTHERN BRAZIL AND VENEZUELA.					


TREND IMPACT ANALYSIS
SHIPMENTS OF ORES (THOU. TONS)
IN HUNDREDS
O=HISTORY
X=NAIVE TREND
-=LOWER PERCENTILE
*=EXPECTED VALUE
+=UPPER PERCENTILE
0 INTSECT
YEAR
NAIVE CURVE NO.=19   CONFIDENCE PERCENTILES =25 AND 75

SHIPMENTS OF METALS
(Thousands of Tons)

TREND IMPACT ANALYSIS

BASELINE CURVE NO. = 1   CONFIDENCE PERCENTILES = 25 AND 75

YEAR	HISTORY/ BASELINE	◆◆◆ LOWER	FORECAST CENTER	◆◆◆ UPPER
1965	7638.00			
1970	15005.00			
1975	15987.00			
1979	12333.00			
1981	10357.00			
1983	13357.96	11172.70	13213.25	15188.02
1984	13481.73	11206.86	13274.26	15260.96
1985	13605.50	11269.76	13356.57	15351.79
1986	13729.28	11365.36	13460.03	15460.38
1987	13853.05	11482.09	13580.19	15584.52
1988	13976.82	11593.31	13695.24	15702.16
1989	14100.60	11695.69	13805.06	15816.70
1990	14224.37	11797.83	13909.49	15924.97
1991	14348.14	11899.36	14013.67	16032.26
1992	14471.92	12010.13	14119.20	16138.39
1993	14595.69	12087.19	14201.47	16218.96
1994	14719.46	12143.73	14269.29	16287.09
1995	14843.24	12194.32	14333.54	16353.15
1996	14967.01	12235.96	14394.28	16416.94
1997	15090.78	12274.36	14448.70	16474.56
1998	15214.56	12308.43	14502.21	16531.34
1999	15338.33	12341.15	14554.79	16587.27
2000	15462.10	12372.51	14606.45	16642.37
2001	15585.88	12432.52	14680.59	16719.67
2002	15709.65	12535.37	14777.75	16819.00
2003	15833.42	12597.75	14853.37	16897.83
2004	15957.20	12629.70	14906.96	16955.13
2005	16080.97	12660.30	14959.72	17011.69
2006	16204.74	12685.43	15007.61	17063.45
2007	16328.52	12704.86	15050.41	17110.21
2008	16452.29	12718.30	15097.98	17151.88
2009	16576.06	12725.51	15120.27	17189.39
2010	16699.84	12726.24	15147.17	17219.64

SHIPMENTS OF METALS (THOU. TONS)

EVENT NO.	YEAR/PROB	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
RELATIVE IMPACT						
2	1990 0.35	0	1	-20.0%	3	-3.0%
	2000 0.65					
	2010 0.80					
-0.843E+04						

PROTECTIONIST SENTIMENT IN US GROWS, CAUSING IMPORT RESTRICTIONS ON CERTAIN IMPORTS (INCLUDING STEEL MANUFACTURES)

EVENT NO.	YEAR/PROB	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
1	1990 0.30	5	15	-7.0%	15	-7.0%
	2000 0.50					
	2010 0.95					
-0.643E+04						

PANAMA CANAL TOLL INCREASE GREATER THAN 25%

EVENT NO.	YEAR/PROB	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
4	1990 0.15	5	15	-10.0%	15	-10.0%
	2000 0.40					
	2010 0.75					
-0.604E+04						

SUBSTANTIAL INVESTMENT I US STEEL INDUSTRY INCREASES CAPACITY TO 80% (1981=60%)

EVENT NO.	YEAR/PROB	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
6	1990 0.10	0	3	-10.0%	5	-3.0%
	2000 0.25					
	2010 0.40					
-0.354E+04						

U.S. ECONOMY EXPERIENCES 5% GROWTH FOR FOUR CONSECUTIVE YEARS.

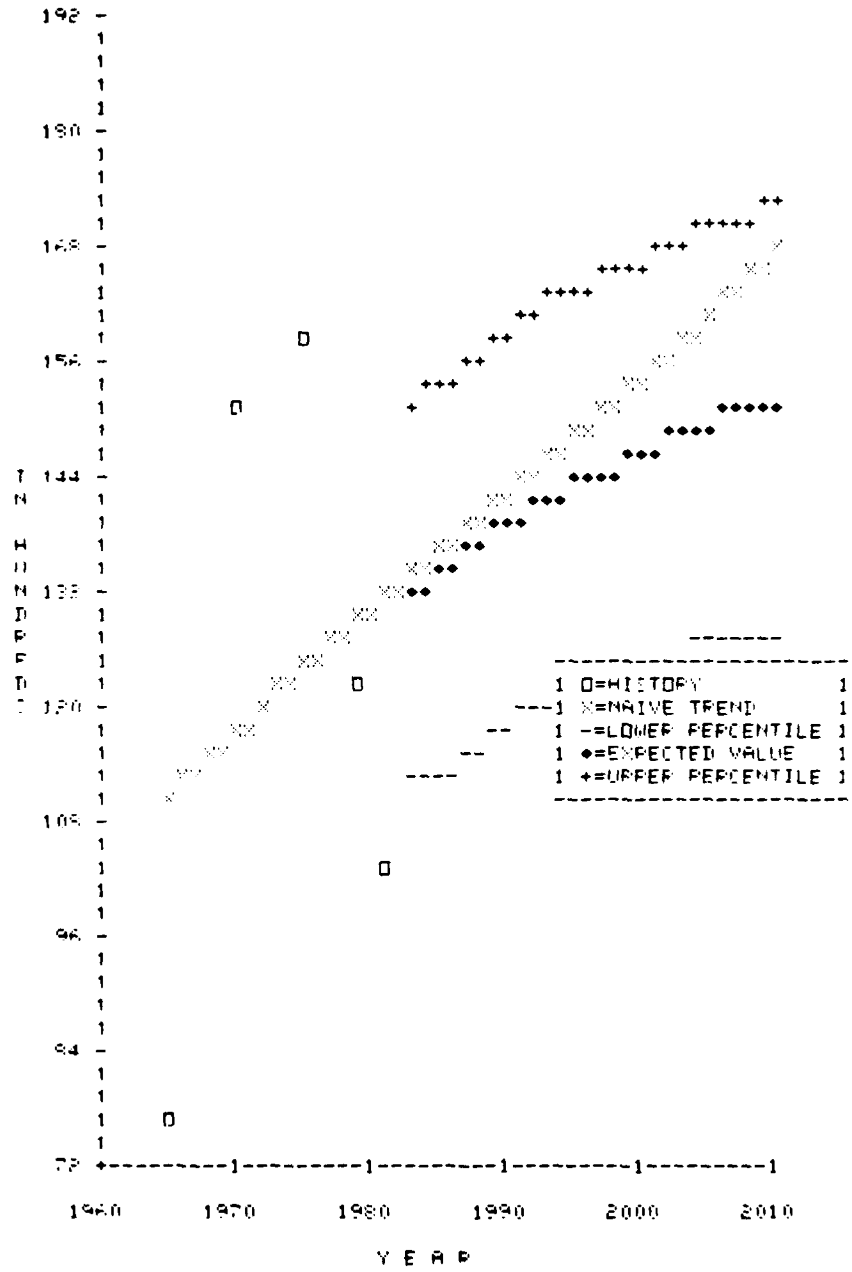
EVENT NO.	YEAR/PROB	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
5	1990 0.30	1	3	-10.0%	5	0. %
	2000 0.60					
	2010 0.90					
-0.309E+04						

WORLD-WIDE DEPRESSION

EVENT NO.	YEAR/PROB	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
7	1990 0.25	0	2	10.0%	5	5.0%
	2000 0.40					
	2010 0.55					
0.801E+04						

US STEEL INDUSTRY EXPERIENCES SHARP DROP IN PRODUCTION DUE TO LABOR UNREST

TREND IMPACT ANALYSIS
SHIPMENTS OF METALS (THOU. TONS)



NAIVE CURVE NO.= 1   CONFIDENCE PERCENTILES =25 AND 75

SHIPMENTS OF PHOSPHATES AND FERTILIZERS
(Thousands of Tons)

TREND IMPACT ANALYSIS

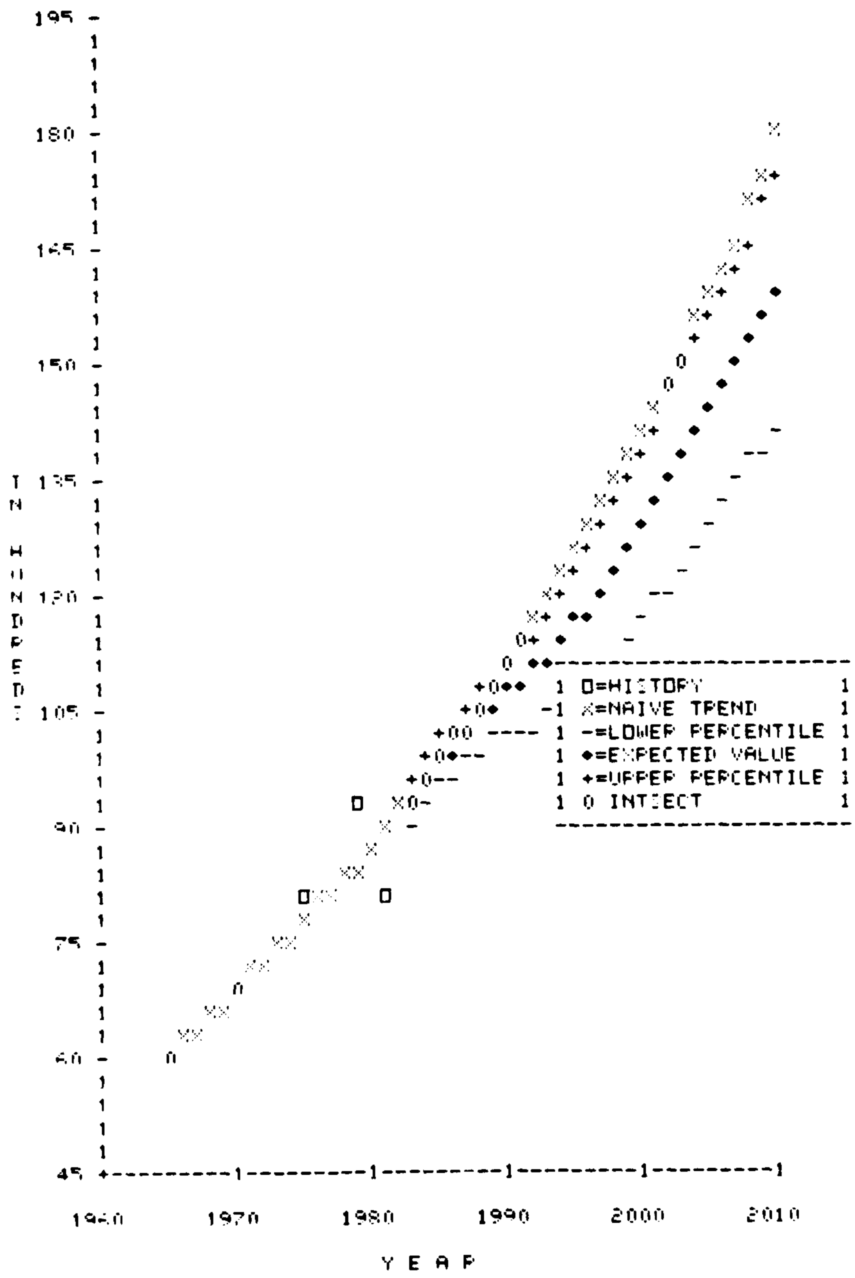
BASELINE CURVE NO. = 2   CONFIDENCE PERCENTILES = 25 AND 75

YEAR	HISTORY/ BASELINE	*** LOWER	FORECAST CENTER	*** UPPER
1965	5975.00			
1970	6969.00			
1975	7994.00			
1979	9198.00			
1981	9242.00			
1983	9401.81	9093.04	9395.69	9698.39
1984	9627.73	9301.16	9608.93	9911.75
1985	9859.08	9496.56	9815.11	10118.24
1986	10095.99	9684.62	10020.19	10323.83
1987	10338.59	9850.97	10216.14	10521.70
1988	10587.02	9987.93	10402.07	10713.48
1989	10841.42	10087.70	10573.45	10897.30
1990	11101.93	10169.95	10736.69	11081.51
1991	11369.70	10243.59	10897.36	11272.98
1992	11641.88	10309.68	11057.06	11474.42
1993	11921.63	10395.04	11228.85	11697.47
1994	12208.10	10501.39	11416.19	11945.72
1995	12501.45	10624.62	11616.69	12216.90
1996	12801.86	10773.67	11838.92	12519.12
1997	13109.42	10951.18	12094.23	12853.14
1998	13424.49	11151.66	12345.28	13190.09
1999	13747.07	11375.67	12622.00	13532.21
2000	14077.41	11619.78	12912.12	13878.56
2001	14415.68	11886.16	13216.27	14230.31
2002	14762.08	12148.63	13517.77	14572.05
2003	15116.80	12405.22	13816.91	14909.77
2004	15480.05	12652.32	14110.60	15239.93
2005	15852.02	12899.34	14406.05	15569.04
2006	16232.94	13147.55	14707.99	15901.43
2007	16623.01	13404.64	15021.81	16250.82
2008	17022.45	13665.72	15343.78	16613.84
2009	17431.49	13931.05	15674.15	16991.09
2010	17850.35	14206.44	16016.15	17385.87

SHIPMENTS OF PHOSPHATES&FERTILIZERS(THOU TONS)

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
4	1990 0.30 2000 0.50 2010 0.80	3	8	-10.0%	8	-10.0%
-0.123E+05	EXPORT OF PHOSPHATE ROCK BY COMBINATION BULK CARRIERS VIA CAPE HORN					
3	1990 0.50 2000 0.70 2010 0.80	5	10	-10.0%	20	-5.0%
-0.115E+05	DEVELOPMENT OF PHOSPHATE ROCK DEPOSITS IN THE ROCKY MOUNTAIN AREA					
1	1990 0.20 2000 0.40 2010 0.60	1	7	-10.0%	10	-5.0%
-0.694E+04	LIMITS ON US EXPORTS OF PHOSPHATE (E.G., CONSERVATION OF NATURAL RESOURCES)					
2	1990 0.30 2000 0.40 2010 0.50	5	10	-5.0%	10	-5.0%
-0.456E+04	DEVELOPMENT OF NEW MARKETS AND SOURCES OF FERTILIZERS					
6	1990 0.30 2000 0.50 2010 0.95	1	3	-3.0%	6	0. %
-0.101E+04	PANAMA CANAL TOLL INCREASE OF GREATER THAN 25%					
5	1990 0.30 2000 0.50 2010 0.80	5	15	15.0%	20	10.0%
0.114E+05	INCREASE IN WORLDWIDE AGRICULTURAL ACREAGE AND PRODUCTION, CAUSING A GREATER DEMAND FOR FERTILIZER					

T R E N D   I M P A C T   A N A L Y S I S
SHIPMENTS OF PHOSPHATES&FERTILIZERS(THOU TONS)



NAIVE CURVE NO.= 2   CONFIDENCE PERCENTILES =25 AND 75

SHIPMENTS OF LUMBER, PULP, PAPER
(Thousands of Tons)

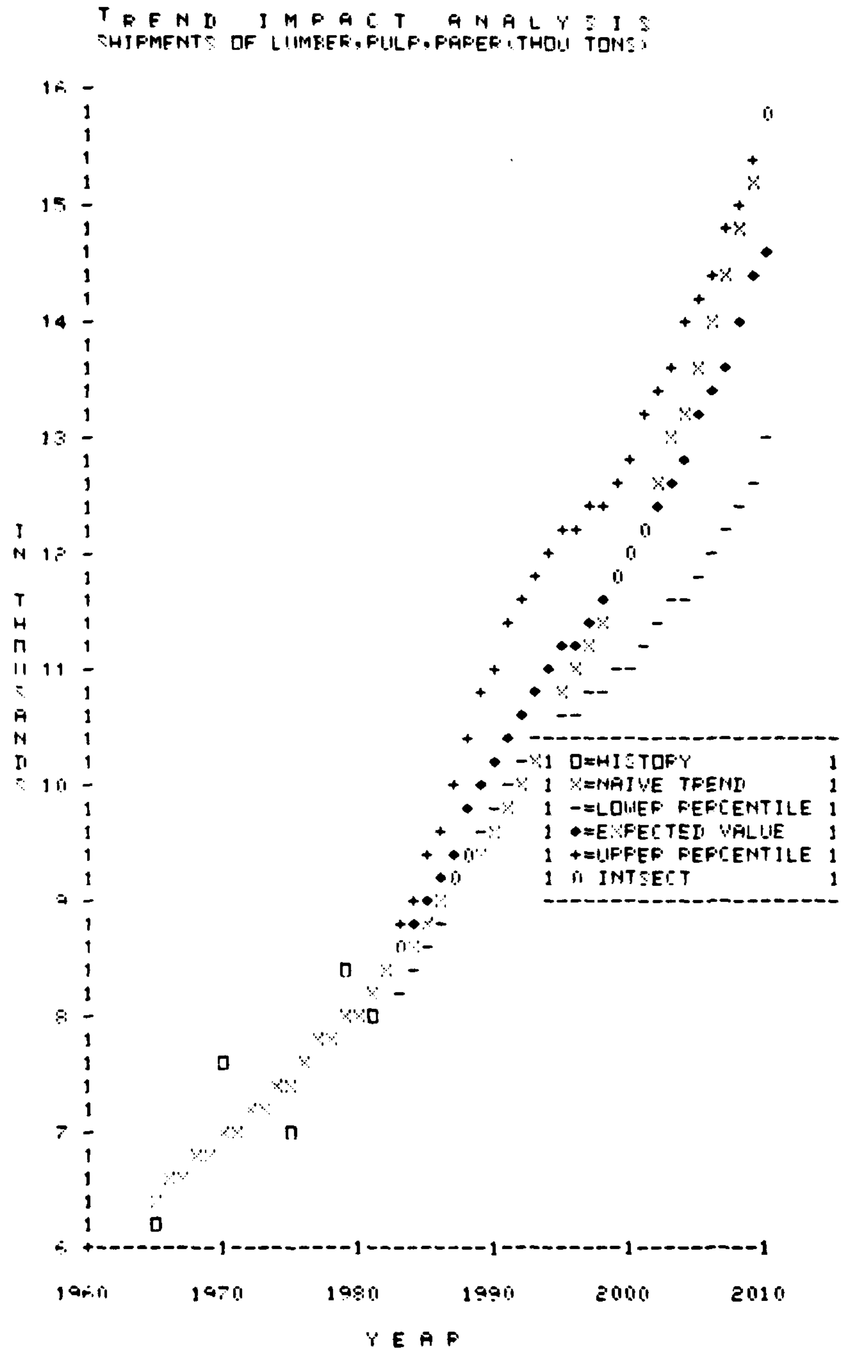
TREND IMPACT ANALYSIS

BASELINE CURVE NO. = 6   CONFIDENCE PERCENTILES = 25 AND 75

YEAR	HISTORY/ BASELINE	*** LOWER	FORECAST CENTER	*** UPPER
1965	6234.00			
1970	7585.00			
1975	7038.00			
1979	8410.00			
1981	7934.00			
1983	8511.68	8238.94	8532.01	8831.54
1984	8661.11	8426.55	8723.18	9051.48
1985	8815.72	8637.23	8942.08	9329.81
1986	8975.78	8870.61	9190.20	9669.43
1987	9141.60	9121.11	9463.98	10063.77
1988	9313.48	9362.44	9728.40	10418.85
1989	9491.76	9592.48	9982.93	10745.22
1990	9676.82	9809.26	10226.96	11047.70
1991	9869.03	10010.96	10459.85	11329.85
1992	10063.84	10175.14	10659.90	11566.52
1993	10276.68	10320.91	10842.95	11780.32
1994	10493.07	10447.36	11007.94	11963.63
1995	10719.53	10553.47	11153.69	12108.65
1996	10953.66	10640.41	11281.07	12207.44
1997	11199.08	10735.71	11425.24	12333.86
1998	11455.48	10840.10	11586.54	12499.13
1999	11723.63	10955.11	11766.16	12674.86
2000	12004.35	11088.29	11965.42	12898.25
2001	12298.53	11223.21	12185.72	13142.09
2002	12607.18	11359.53	12408.94	13395.69
2003	12931.39	11504.49	12640.65	13656.38
2004	13272.37	11658.40	12881.53	13922.72
2005	13631.44	11821.68	13132.27	14193.04
2006	14010.10	11996.06	13394.75	14466.34
2007	14409.99	12198.31	13680.03	14767.55
2008	14832.93	12412.33	13990.11	15098.79
2009	15281.00	12658.27	14327.22	15462.32
2010	15756.49	12932.56	14693.84	15960.62

SHIPMENTS OF LUMBER,PULP,PAPER(THOU TONS)

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
2	1990 0.40	5	20	-15.0%	20	-15.0%
	2000 0.70					
	2010 0.80					
-0.125E+05	SHIFTING MARKETS AND SOURCES FOR PAPER, PULP, AND LUMBER (E.G., WESTERN CANADA SUPPLYING THE FAR-EAST; EASTERN CANADA AND USSR SUPPLYING EUROPE AND US EAST COAST)					
4	1990 0.50	1	10	-5.0%	15	-3.0%
	2000 0.80					
	2010 0.80					
-0.621E+04	INCREASE IN OVERLAND RAIL SHIPMENTS FROM WESTERN CANADA TO E. COAST U.S.					
1	1990 0.30	5	15	-5.0%	15	-5.0%
	2000 0.50					
	2010 0.95					
-0.383E+04	PANAMA CANAL TOLL INCREASE OF GREATER THAN 25%					
3	1990 0.80	1	5	15.0%	10	8.0%
	2000 0.95					
	2010 0.95					
0.225E+05	LARGE INCREASE IN WESTERN CANADIAN LUMBER SHIPMENTS THROUGH THE PANAMA CANAL (E.G., DUE TO DEPLETION OF TROPICAL RAIN FORESTS)					



NAIVE CURVE NO.= 6   CONFIDENCE PERCENTILES =25 AND 75

SHIPMENTS OF BANANAS
(Thousands of Tons)

TREND IMPACT ANALYSIS

BASELINE CURVE NO. = 1 CONFIDENCE PERCENTILES = 25 AND 75

YEAR	HISTORY/ BASELINE	*** LOWER	FORECAST CENTER	*** UPPER
1965	1319.00			
1970	1237.00			
1975	1683.00			
1979	1468.00			
1981	1127.00			
1983	1371.67	1215.61	1356.81	1487.50
1984	1372.21	1199.41	1348.90	1481.34
1985	1372.75	1187.33	1342.08	1474.72
1986	1373.29	1176.06	1335.34	1468.23
1987	1373.83	1164.75	1328.05	1461.28
1988	1374.37	1153.16	1320.21	1453.93
1989	1374.91	1141.10	1311.82	1446.22
1990	1375.45	1128.93	1303.13	1438.45
1991	1375.99	1114.63	1292.92	1429.43
1992	1376.53	1097.99	1281.18	1419.21
1993	1377.07	1076.59	1267.01	1406.51
1994	1377.61	1055.56	1252.89	1393.89
1995	1378.15	1035.06	1238.93	1381.33
1996	1378.70	1015.23	1225.38	1369.11
1997	1379.24	995.99	1212.23	1357.23
1998	1379.78	978.55	1200.24	1346.51
1999	1380.32	962.81	1189.38	1336.96
2000	1380.86	948.74	1179.65	1328.59
2001	1381.40	936.99	1171.63	1321.96
2002	1381.94	926.61	1164.50	1316.14
2003	1382.48	917.60	1158.05	1310.90
2004	1383.02	908.29	1151.33	1305.36
2005	1383.56	899.70	1144.34	1299.50
2006	1384.10	888.36	1136.60	1292.85
2007	1384.64	876.88	1127.90	1285.22
2008	1385.18	864.23	1118.25	1276.62
2009	1385.72	850.40	1107.63	1267.04
2010	1386.27	835.38	1096.07	1256.48

SHIPMENTS OF BANANAS (THOU.TONS)

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EVENT  YEAR/PROB   YRS TO   YRS TO    MAXIMUM  YRS TO    STEADY
 NO.               FIRST    MAXIMUM   IMPACT   STEADY    STATE
         RELATIVE  IMPACT   IMPACT             STATE     IMPACT
         IMPACT                                IMPACT

    6  1990 0.15      0        2       -25.0%   10       -10.0%
       2000 0.45
       2010 0.70
 -0.195E+04
       IMPOSITION OF EXPORT TAX ON BANANAS GROWN IN ECUADOR.

    1  1990 0.30      5       15       -15.0%   15       -15.0%
       2000 0.50
       2010 0.95
 -0.120E+04
       PANAMA CANAL TOLL INCREASE OF MORE THAN 25%

    7  1990 0.25      0        1       -20.0%    3        -5.0%
       2000 0.50
       2010 0.75
 -0.107E+04
       ONE WEEK DELAYS IN PANAMA CANAL TRANSIT LASTS FOR
       SIX MONTHS.

    5  1990 0.25      3       10       -10.0%   20        -5.0%
       2000 0.40
       2010 0.65
      -681.
       DEVELOPMENT OF PACIFIC BASIN MARKETS FOR ECUADORAN
       BANANA PRODUCTION

    3  1990 0.10      2        7       -10.0%    7       -10.0%
       2000 0.20
       2010 0.30
      -462.
       ATLANTIC BASIN BANANA PRODUCERS ATTEMPT TO GAIN CONTROL
       OF EUROPEAN MARKETS BY INCREASING PRODUCTION BY 50%

    4  1990 0.10      0        2        15.0%    3         3.0%
       2000 0.20
       2010 0.30
       273.
       FAD IN EUROPE RESULTS IN INCREASED BANANA CONSUMPTION.

    2  1990 0.20      3       10        10.0%   15         8.0%
       2000 0.50
       2010 0.75
       831.
       TECHNOLOGICAL IMPROVEMENTS RESULT IN INCREASED SHELF
       LIFE FOR BANANAS.
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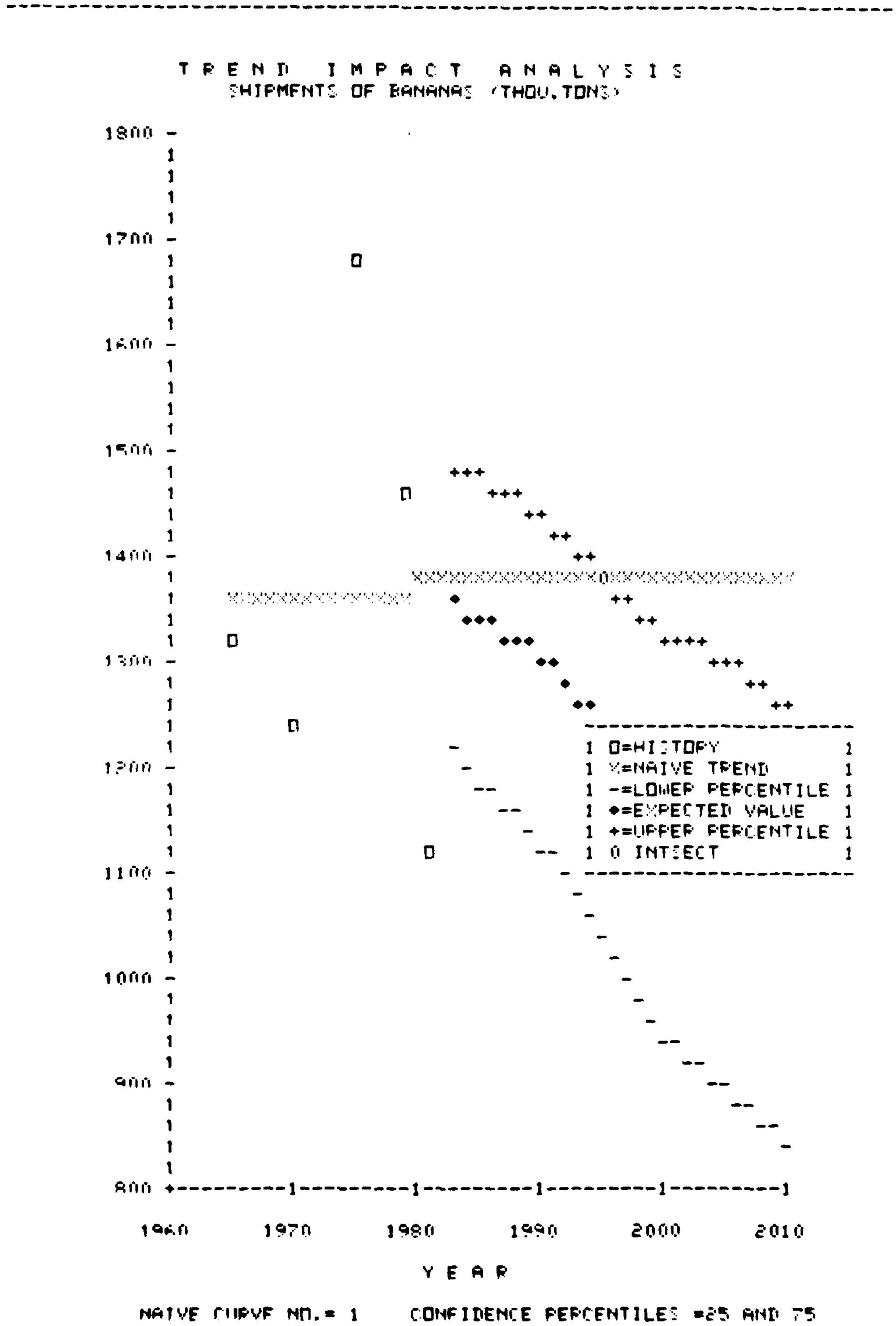


TREND IMPACT ANALYSIS
SHIPMENTS OF BANANAS (THOU.TONS)
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
1960
1970
1980
1990
2000
2010
YEAR
D=HISTORY
X=NAIVE TREND
-=LOWER PERCENTILE
◆=EXPECTED VALUE
+=UPPER PERCENTILE
0 INTSECT
NAIVE CURVE NO.= 1
CONFIDENCE PERCENTILES =25 AND 75

SHIPMENTS OF MISCELLANEOUS BULK MATERIAL
(Thousands of Tons)

TREND IMPACT ANALYSIS

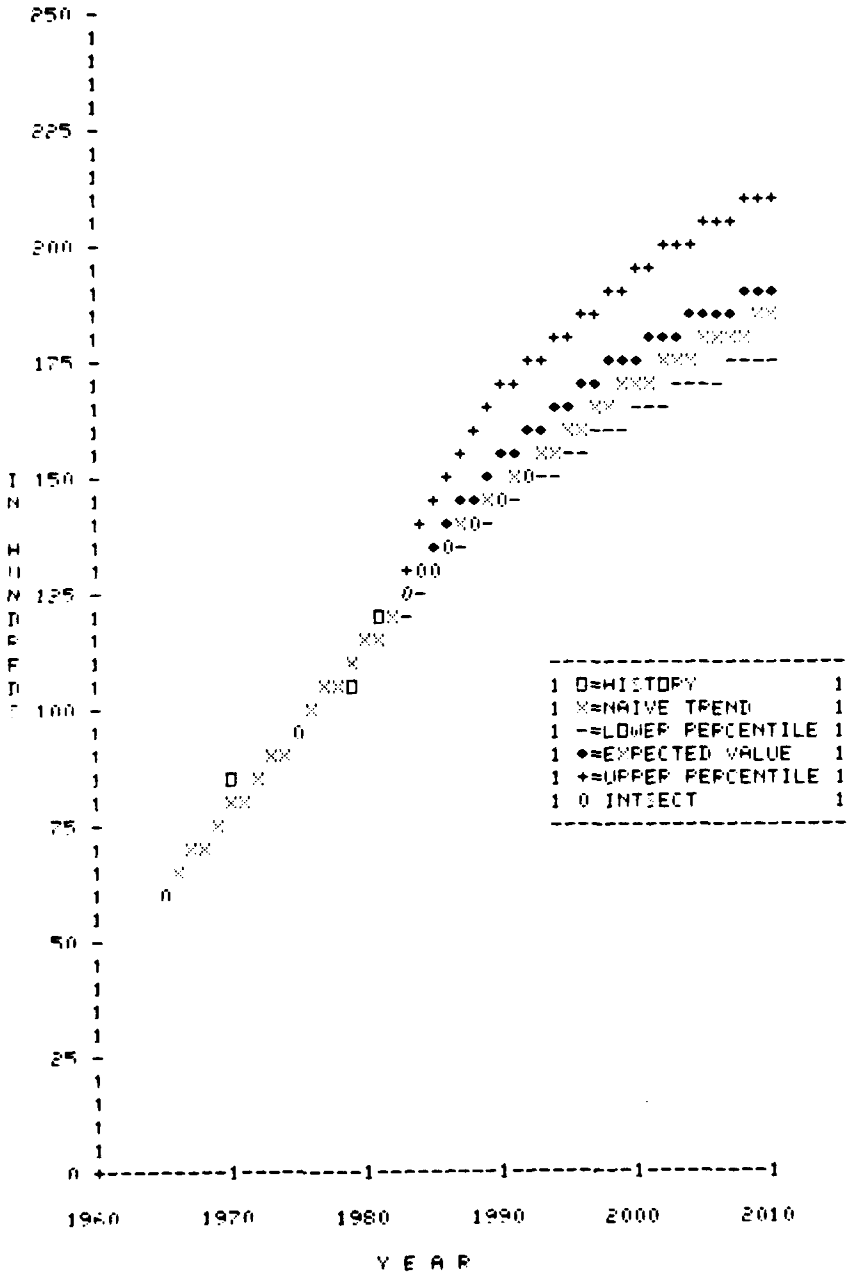
BASELINE CURVE NO. = 14   CONFIDENCE PERCENTILES = 25 AND 75

YEAR	HISTORY/ BASELINE	*** LOWER	FORECAST CENTER	*** UPPER
1965	5890.00			
1970	8393.00			
1975	9447.00			
1979	10450.00			
1981	12131.00			
1983	12441.91	12248.39	12555.50	13013.78
1984	12781.23	12696.09	13065.61	13830.20
1985	13113.76	13037.45	13531.59	14474.[illegible]7
1986	13439.83	13410.77	13949.01	15018.38
1987	13755.86	13656.37	14311.65	15483.23
1988	14064.34	13907.07	14662.71	15928.82
1989	14363.82	14156.49	15001.39	16355.70
1990	14653.94	14401.03	15326.99	16764.16
1991	14934.39	14639.96	15640.53	17156.35
1992	15204.94	14834.16	15893.56	17467.41
1993	15465.43	14990.35	16092.07	17642.20
1994	15715.75	15152.57	16305.72	17860.48
1995	15955.97	15357.42	16541.16	18119.41
1996	16185.80	15602.70	16800.94	18415.62
1997	16405.60	15927.87	17046.10	18699.64
1998	16615.39	16039.42	17280.79	18972.36
1999	16815.30	16237.51	17505.09	19236.66
2000	17005.54	16422.46	17719.17	19491.51
2001	17186.31	16586.11	17914.60	19726.61
2002	17357.87	16718.27	18076.59	19915.09
2003	17520.47	16826.58	18212.29	20056.35
2004	17674.41	16935.71	18347.53	20206.20
2005	17819.99	17046.94	18482.82	20362.09
2006	17957.49	17159.45	18616.88	20519.27
2007	18087.26	17264.39	18743.02	20669.19
2008	18209.61	17361.99	18861.63	20812.09
2009	18324.85	17452.46	18973.05	20948.19
2010	18433.32	17536.03	19077.67	21077.76

SHIPMENTS OF MISC. BULK MATERIAL (THOU TONS)

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
5	1990 0.75 2000 0.90 2010 0.99	1	5	-10.0%	10	-8.0%
-0.265E+05	REARRANGEMENT OF MARKETS AND SOURCES FOR SUGAR(E.G.,CUBA-CHINA					
4	1990 0.30 2000 0.50 2010 0.95	5	15	-5.0%	15	-5.0%
-0.505E+04	PANAMA CANAL TOLL INCREASE OF MORE THAN 25%					
3	1990 0.10 2000 0.30 2010 0.50	1	15	-5.0%	20	-2.0%
-0.259E+04	U.S. WEST COAST PORT EXPANSION					
6	1990 0.25 2000 0.55 2010 0.75	0	1	10.0%	5	0. %
0.342E+04	DISRUPTION IN SERVICE OF MINI-BRIDGE					
2	1990 0.40 2000 0.70 2010 0.90	2	5	10.0%	10	5.0%
0.137E+05	SUBSTANTIAL GROWTH IN WORLD TRADE					
1	1990 0.60 2000 0.85 2010 0.99	1	2	20.0%	5	10.0%
0.340E+05	TRANSPORTATION COSTS FOR THE MINI-BRIDGE INCREASE SUBSTANTIALLY					

T R E N D   I M P A C T   A N A L Y S I S
SHIPMENTS OF MISC. BULK MATERIAL (THOU TONS)



NAIVE CURVE NO.=14   CONFIDENCE PERCENTILES =25 AND 75

SHIPMENTS OF AUTOMOBILES
(Thousands of Tons)

TREND IMPACT ANALYSIS

BASELINE CURVE NO. = 14   CONFIDENCE PERCENTILES = 25 AND 75

YEAR	HISTORY/ BASELINE	*** LOWER	FORECAST CENTER	*** UPPER
1965	413.00			
1970	1023.00			
1975	1529.00			
1979	1555.00			
1981	1796.00			
1983	2050.26	1948.61	2049.35	2150.21
1984	2132.09	2027.33	2129.25	2231.82
1985	2209.58	2093.93	2203.69	2310.37
1986	2282.49	2162.31	2272.35	2386.52
1987	2350.64	2209.41	2328.79	2454.61
1988	2413.99	2238.31	2371.99	2509.69
1989	2472.54	2248.72	2401.14	2551.29
1990	2526.39	2238.34	2416.21	2579.12
1991	2575.68	2207.57	2416.91	2593.03
1992	2620.62	2159.39	2405.66	2595.32
1993	2661.42	2112.74	2391.87	2594.18
1994	2698.34	2067.42	2376.11	2589.96
1995	2731.64	2023.58	2358.95	2592.99
1996	2761.58	1986.97	2346.03	2578.64
1997	2788.45	1956.87	2336.96	2577.67
1998	2812.49	1933.54	2331.76	2590.02
1999	2833.97	1917.93	2330.89	2596.05
2000	2853.11	1910.91	2334.75	2596.07
2001	2870.15	1913.37	2343.70	2610.36
2002	2885.29	1911.77	2348.59	2620.29
2003	2899.72	1906.25	2349.54	2625.70
2004	2910.63	1896.95	2346.69	2626.43
2005	2921.18	1884.00	2340.16	2622.32
2006	2930.52	1869.38	2331.83	2614.94
2007	2938.77	1856.03	2324.31	2608.26
2008	2946.06	1844.24	2317.73	2602.44
2009	2952.49	1834.26	2312.21	2597.57
2010	2958.17	1826.37	2307.84	2593.76

SHIPMENTS OF AUTOMOBILES (THOU. TONS)

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
5	1990 0.70	5	10	-15.0%	10	-15.0%
	2000 0.90					
	2010 0.95					

-0.595E+04
INCREASE IN FOREIGN OWNED AUTOMOBILE MANUFACTURING PLANTS IN THE US

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
7	1990 0.60	1	10	-10.0%	10	-10.0%
	2000 0.70					
	2010 0.80					

-0.363E+04
INCREASE IN JAPANESE EXPORTS TO THE US WEST COAST, WITH LAND-BASED DISTRIBUTION TO EASTERN MARKETS

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
4	1990 0.80	1	5	-5.0%	5	-5.0%
	2000 0.80					
	2010 0.80					

-0.245E+04
RENEWAL ON AGREEMENT WITH JAPAN ON EXPORT CONTROLS FOR AUTOMOBILES

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
6	1990 0.40	5	10	-8.0%	15	-5.0%
	2000 0.50					
	2010 0.50					

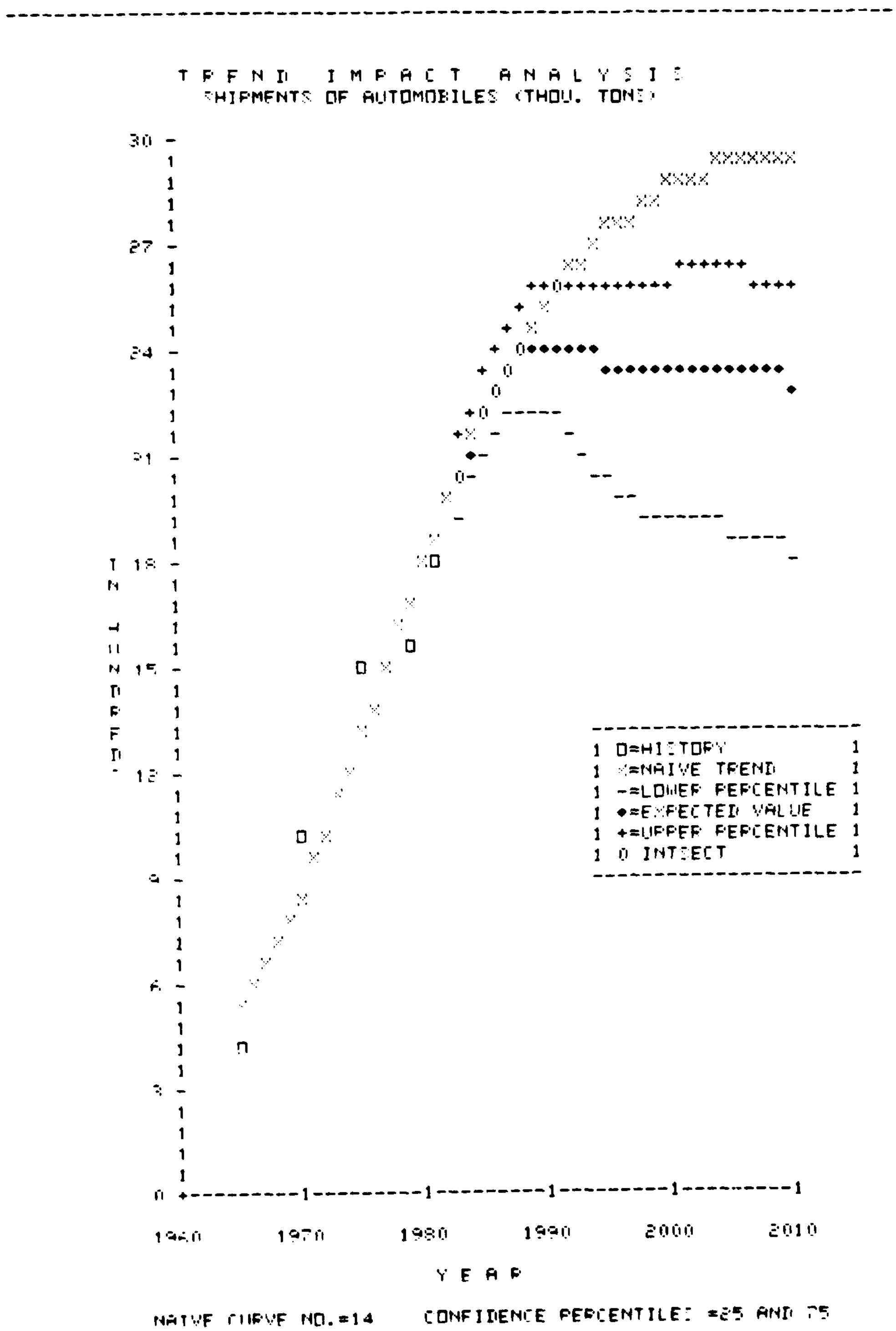
-0.134E+04
US CONSUMER TASTE RETURNS TO LARGER US-MADE AUTOMOBILES

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
3	1990 0.30	5	15	-3.0%	15	-3.0%
	2000 0.80					
	2010 0.95					

-641.
PANAMA CANAL TOLL INCREASE OF GREATER THAN 25%

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
1	1990 0.50	1	5	10.0%	5	10.0%
	2000 0.80					
	2010 0.50					

0.415E+04
GREATER USE OF LARGE PURE AUTOMOBILE BULK CARRIERS


T R E N D   I M P A C T   A N A L Y S I S
SHIPMENTS OF AUTOMOBILES (THOU. TONS)
30
27
24
21
18
15
12
9
6
3
0
T
H
O
U
S
A
N
D
S
1960
1970
1980
1990
2000
2010
Y E A R
D=HISTORY
X=NAIVE TREND
-=LOWER PERCENTILE
◆=EXPECTED VALUE
+=UPPER PERCENTILE
0 INTSECT
NAIVE CURVE NO.=14
CONFIDENCE PERCENTILES =25 AND 75

SHIPMENTS OF GENERAL CARGO AND ALL OTHER
(Thousands of Tons)

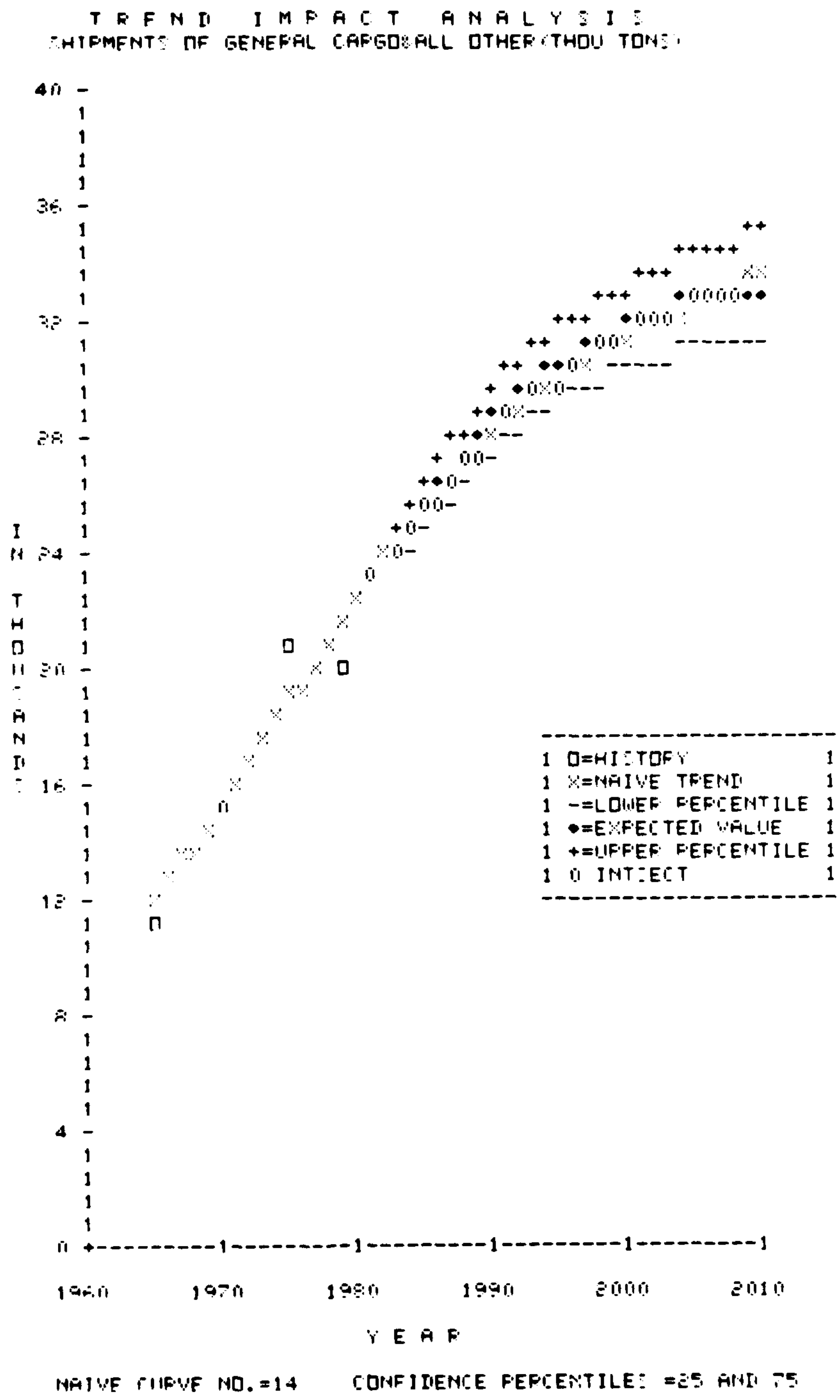
TREND IMPACT ANALYSIS

BASELINE CURVE NO. = 14 CONFIDENCE PERCENTILES = 25 AND 75

YEAR	HISTORY/ BASELINE	*** LOWER	FORECAST CENTER	*** UPPER
1965	11577.00			
1970	15263.00			
1975	20495.00			
1979	20354.00			
1981	23125.00			
1983	24222.95	23635.65	24272.52	24938.97
1984	24821.51	24203.39	24899.77	25628.51
1985	25400.01	24775.64	25519.90	26314.22
1986	25957.61	25369.62	26143.40	27011.72
1987	26493.66	25959.84	26759.73	27709.73
1988	27007.72	26514.62	27344.29	28366.91
1989	27499.51	27035.29	27895.92	28994.53
1990	27968.92	27527.00	28421.44	29575.58
1991	28415.95	27969.63	28900.77	30116.93
1992	28840.88	28362.15	29332.02	30601.16
1993	29243.91	28704.06	29713.29	31020.84
1994	29625.48	28993.23	30055.29	31401.07
1995	29986.09	29254.91	30370.62	31753.68
1996	30326.33	29493.78	30664.37	32083.46
1997	30646.53	29702.62	30932.09	32388.51
1998	30948.29	29896.97	31184.64	32676.36
1999	31231.43	30076.76	31419.09	32946.52
2000	31497.04	30242.83	31637.40	33199.92
2001	31745.87	30390.17	31834.63	33430.91
2002	31978.72	30543.35	32031.57	33658.22
2003	32196.32	30709.77	32227.99	33880.04
2004	32399.64	30866.89	32413.96	34090.73
2005	32589.26	30992.95	32574.87	34276.14
2006	32766.01	31097.61	32712.50	34437.86
2007	32930.62	31180.41	32835.04	34593.99
2008	33083.82	31253.70	32943.21	34715.25
2009	33226.28	31313.81	33037.69	34832.40
2010	33358.68	31361.09	33119.19	34936.14

SHIPMENTS OF GENERAL CARGO/ALL OTHER (THOU TONS)

EVENT NO.	YEAR/PROB RELATIVE IMPACT	YRS TO FIRST IMPACT	YRS TO MAXIMUM IMPACT	MAXIMUM IMPACT	YRS TO STEADY STATE IMPACT	STEADY STATE IMPACT
3	1990 0.35 2000 0.65 2010 0.80 -0.131E+05	1	2	-5.0%	4	-3.0%
	PROTECTIONIST SENTIMENT INCREASES IN U.S. TOWARD JAPANESE IMPORTS. U.S. IMPOSES IMPORT RESTRICTIONS					
6	1990 0.30 2000 0.50 2010 0.95 -0.927E+04	5	15	-5.0%	15	-5.0%
	PANAMA CANAL TOLL INCREASE OF MORE THAN 25%.					
5	1990 0.15 2000 0.45 2010 0.60 -0.636E+04	1	3	-5.0%	5	-2.0%
	REARRANGEMENT OF MARKETS AND SOURCES FOR GENERAL CARGO.					
4	1990 0.10 2000 0.30 2010 0.50 -0.501E+04	1	15	-5.0%	20	-3.0%
	U.S. WEST COAST PORT EXPANSION					
7	1990 0.25 2000 0.50 2010 0.75 0.970E+04	2	5	5.0%	7	3.0%
	U.S. ECONOMIC POLICY TOWARD SOUTH AMERICA INVOLVES EXPANSION OF TRADE BETWEEN U.S. AND CHILE/PERU/ECUADOR					
1	1990 0.60 2000 0.85 2010 0.99 0.239E+05	0	2	5.0%	2	5.0%
	TRANSPORTATION COSTS FOR MINIBRIDGE INCREASE SUBSTANTIALLY					


T R E N D   I M P A C T   A N A L Y S I S
SHIPMENTS OF GENERAL CARGO&ALL OTHER(THOU TONS)
40
36
32
28
24
20
16
12
8
4
0
IN THOUSANDS
1960
1970
1980
1990
2000
2010
Y E A R
O=HISTORY
X=NAIVE TREND
-=LOWER PERCENTILE
*=EXPECTED VALUE
+=UPPER PERCENTILE
0 INTIECT
NAIVE CURVE NO.=14   CONFIDENCE PERCENTILES =25 AND 75

TOTAL COMMODITY SHIPMENTS FOR 2010

Commodity	TIA Median Forecast (thousand tons)	TIA Forecast Range (thousand tons)	
Grains & Soybeans	59,430	Upper	64,095
		Lower	45,994
Petroleum & Petroleum Products	36,746	Upper	50,231
		Lower	8,757
Coal	33,369	Upper	42,484
		Lower	26,140
Ores	6,581	Upper	8,057
		Lower	5,457
Metals	15,147	Upper	17,219
		Lower	12,726
Phosphates & Fertilizers	16,016	Upper	17,385
		Lower	14,206
Lumber, Pulp & Paper	14,693	Upper	15,860
		Lower	19,932
Bananas	1,096	Upper	1,256
		Lower	835
Miscellaneous Bulk Material	19,077	Upper	21,077
		Lower	17,536
Automobiles	2,307	Upper	2,593
		Lower	1,826
General Cargo	33,119	Upper	34,936
		Lower	31,361
New Movements	10,000		
Total Shipments	247,581		

PROJECTED NUMBER OF SHIP TRANSITS

The capacity of the Panama Canal is measured in terms of the number of ship transits and the size of ships. However, since the level and size of ship transits depend on the level and type of commodity shipments, the transits can not be directly forecasted without first understanding commodity traffic in the future. The purpose of the foregoing commodity projections is to provide this base of reference.

The relationship between ship transits and commodity traffic, however, is not simply linear. For many years now the tonnage of commodities shipped through the Panama Canal has increased at a sharp rate, while the number of ships has increased at a much slower rate. Since 1960, for instance, cargo tonnage has more than tripled from about 59 million tons to over 185 million tons in 1982. The number of commercial transits has increased by only 30 percent, from 10,975 ships to about 14,300. These divergent trends were largely the result of: a change in the commodity mix, with more shipments of bulk materials using larger bulk carriers, and less general cargo; a change from general cargo ships to container ships, also involving a shift to larger ship size; and a trend within each category of ships toward larger size. These trends are continuing and it is likely that over the next 30 years tonnage will increase more rapidly than ship numbers.

The process of converting tonnage into ship transits is made possible by the fact that there are five major types of ships using the canal and most commodity shipments are associated with one of these types. The major ship types are: general cargo, container, refrigerator, bulk and tanker. In assigning commodities to each ship type, we have taken into account the historical trends cited earlier, as

well as several future developments that are likely to influence the ship number projection:

a. There will be fewer tankers in the total, particularly tankers carrying crude oil. Since these are generally very large ships, on average, this trend will tend to increase the ship number.

b. There will be fewer refrigerator ships, including banana ships in the total. This will have the opposite effect, since refrigerator ships are small and much below average size.

c. There will be fewer transits in ballast, since both crude oil tankers and small refrigerator ships have a high ballast return ratio. This trend will reduce the number of ships. This is an important factor because a small change in ballast ratio can translate into many ships.

With these constraints in mind, we have attempted to project, for 2010, the number of ship transits that would be consistent with the tonnage projection of 247 million tons. Our estimate is between 17,300 and 17,800 commercial transits, as against about 14,000 in 1981. This projection of ship numbers assumes that a 44 percent increase in tonnage--between 1981 and 2010--can be accommodated with a 24-27 percent increase in ship numbers. Obviously, this is a very tentative projection, given the uncertainties in forecasting both commoditiy volumes and shipping trends.

TRANSPORTATION ALTERNATIVES

Introduction

The first group of transportation alternatives does not utilize the Canal. The non-Canal alternatives are of two types--non-vehicular and vehicular. The non-vehicular options include pipelines (primarily petroleum), slurry pipelines and conveyor belts. The vehicular options include landbridge systems (railroads and trucks) and air cargo systems. These options reduce demand for the Canal by taking traffic away from it while still utilizing the Panamanian Isthmus. All systems unload cargo from the ships at one end of the Isthmus and reload the same cargo back onto ships on the other side of the Isthmus.

The second group of transportation alternatives that would increase the capacity of the Panamanian Isthmus involve canals--both modifications to the existing Panama Canal and the construction of a new canal, presumably a sea-level canal. These options would have two principal objectives: (1) to increase the number of ships that can utilize the Isthmus and (2) to increase the maximum size of the ships. In addition, there is a discussion of trends in shipping in this section.

NON-CANAL ALTERNATIVES

PIPELINES

General Description

One way to increase the capacity of the Panamanian Isthmus is to decrease the level of certain commodities that ordinarily use the Canal. Pipelines are a method of moving goods by not utilizing the Canal. This presently includes pipelines for oil and potentially slurry pipelines for coal, ores and other minerals. Pipeline systems carrying energy resources are slightly more than a century old. In view of this, it is not surprising that both pipeline technology and the infrastructure surrounding pipelining are well developed--although, it should be added, they are best developed in terms of transporting oil, gas and water.

Pipeline technology continues to improve steadily worldwide. In large part, this is a function of construction, marketing, and operating necessity. Those pipelines that have been permitted, funded and developed in such diverse areas as the Gulf of Mexico, Alaska, Saudi Arabia, and Siberia have necessitated certain engineering and hardware changes.

A pipeline across Panama has been developed by a consortium of U.S. companies, headed by Northville Industries, and the Panamanian government. Northville, which presently operates a transfer terminal for crude oil in Panama, has built a pipeline system with widths of 36 and 40 inches capable of handling 800,000 b/d. The pipeline extends from Charco Azul (the site of an existing terminal where large tankers from Valdez offload into smaller tankers) north and east to Chiriqui Grande on the Atlantic Ocean. In addition, there is offshore storage capacity for 2.5 million barrels and two single-point moving buoys capable of handling 150,000 dwt tankers for tanker loading.

The pipeline was developed specifically to handle the current oversupply of Alaskan crude on the West Coast and is viewed a short-term project, with a 3-year payout period. The long-term prospect for this pipeline is dependent on the amount of crude oil available, especially new discoveries in Alaska and offshore California. The use of the Panama Canal for transportation of crude oil is also dependent on the level of crude available and potential new finds. It is conceivable that as significantly large finds are made, specific pipeline ventures will be developed to transport the oil. This in turn will decrease the necessity of using the Panama Canal for crude shipments and make available an increased number of transits of other commodities.

Future Technological Developments

In terms of the future of pipeline technology, the current literature suggests that:

- Pumps and valves will become more resistant to abrasion, thereby extending operating periods between their replacement.

- New methods will be designed for moving slurries that will take advantage of the energy savings offered by gravity and changes in elevation. These will likely involve the use of tapered pipes and control valves to solve the overspeed problem.

- Developments in solid-state electronics are likely to result in improved performance levels and increased life spans of pipeline control systems, and in decreased costs for control systems.

- Although steel pipes will continue to predominate, largely because of their economy and strength, research is likely to focus on ways to improve corrosion and abrasion resistance that are consistent with the needs and advantages of string welding.

SLURRY PIPELINES

General Description

Another pipeline technology that may serve as a transportation alternative to the Panama Canal is slurry pipelines. A slurry pipeline system is the transportation of solids suspended in liquid (usually water; other media, such as petroleum and methanol, have been considered) via pipeline. Although slurry pipeline systems have been utilized for over 80 years--for mine tailings and disposal, dredging, etc. --slurry pipeline growth has been relatively slow in comparison to conventional liquid pipelines. This is due to more complex technology and limited conditions for attaining economic viability of slurry pipeline systems. In recent years these obstacles have been overcome and several slurry pipelines have been built that have operated successfully (see Table 1). The success of these projects has proven that the technology is sufficiently advanced to proceed with the design and construction of larger projects.

Technology

Slurry pipeline transportation systems consist of four elements: the slurry itself, a slurry preparation plant, a pipeline, and a recovery or separation plant.

Slurry Design. The slurry consists of a vehicle or fluid such as water in which the finely divided solids are suspended. A typical slurry for long distance transport will have a concentration in the region of 50 percent to 70 percent by weight.

Slurry Preparation. The type and complexity of the slurry preparation process will vary depending on the commodity involved and the degree of integration of the producers' operation and the pipeline system. For most

commodities, the process will consist of reducing the material to the required size distribution followed by thickening or dilution in some sort of a stirred vessel to produce the desired concentration. Slurry concentration and positive rejection of oversize material are probably the most important function that will be controlled, but particle size distribution and slurry viscosity will also be checked.

Pipeline Design. The hydraulic design for most major slurry lines must take into account four different flowing conditions. These are: uniform slurry flow throughout the line, batching of different slurries or slurries and liquids, slurry flow with properties changing along the line, and batching of slurries with changing properties. Because of the relatively high friction losses, the optimum design usually dictates that pumping pressures be in the range of 1,000 to 2,000 psi (70-140 kilogram per square centimeter) to minimize the number of pump stations. Such pressures are beyond the range of centrifugal pumps as used on oil pipelines for slurry service. Pump stations are remotely controlled and operate unattended.

Corrosion and erosion control are two factors also requiring attention in slurry pipeline design. Erosion can be controlled or minimized by proper slurry design and by limiting the operating velocity to 6-7 feet (1.3-2.1 meters) per second and will normally occur only with heterogenous slurry moving coarse material or with velocities exceeding 10 to 12 feet (3.0 to 3.6 meters) per second.

Corrosion control techniques will vary depending on the commodities involved, but will usually involve a combination of oxygen removal and inhibitors. Fortunately, materials such as coal or iron ore are natural oxygen absorbing agents and corrosion control methods can be limited to pH control with a nominal use of an inhibitor.

Slurry Separation and Recovery. Of the four elements in a slurry transportation system, solids recovery technology is probably the least advanced. However, processes either have been, or are being developed, for most of the commodities which are now being seriously considered for pipeline transport.

Overview of Slurry Pipeline Technology

Advantages

- Pipe diameter is small for a given application. For example, a 4.5-inch (114 mm) diameter pipe carries 1 million tons of copper concentrate per year; an 18-inch (457 mm) diameter pipe carries more than 5 million tons of coal per year; a 20-inch (508 mm) diameter pipe carries 12 million tons of iron ore per year.

- Solids concentration is generally high. It varies from 50 percent for coal to 60 percent and 70 percent for iron ore.

- Flow velocities are generally low. They range between 4 to 7 feet per second (1.2 to 2.1 meters per second). Therefore, power consumption is generally low due to reduced pipe wall fiction.

- Multifreight pipelines are feasible today because of experience with batching (different slurries sandwiched between slugs of water).

Disadvantages

- Slurry preparation is complex, involving not only the specific gravity of the solid but also pipeline length, slope, and variable flow conditions.

- Unlike true fluid systems, slurry pipelines must operate at all times above certain minimum or critical velocity. This imposes a very narrow range in which a slurry system can operate.

- Pipeline corrosion is a significant problem. Its control is accomplished either by using costly slurry additives or pipeline material, or by limiting the slurry to less corrosive solids (e.g., coal and iron ore).

- Slurry separation and recovery technology remains experimental.

Overview of Slurry Pipeline Economics

Advantages

- Slurry pipelines are a capital-intensive method of transportation (70 percent or more of total cost is capital charges that are amortized at fixed rates) and are therefore relatively immune to escalating costs and inflation.

- Low unit costs occur where large volumes, long distance, and long-term throughput contracts are involved. Favorable economics will generally be associated with commodities having long-term market stability, such as coal and iron ore.

- Slurry pipelines offer high reliability and a high operating factor, with availability in excess of 90 percent.

- Slurry pipelines are highly automated. Therefore operating costs, particularly the labor content of these costs, are relatively low, and the system is less vulnerable to labor strife or labor cost escalation.

- Since a pipeline is buried, land alienation is minimized and pipelines operate quietly, with minimal pollution (only that associated with slurry recovery) and have an excellent safety record.

Disadvantages

- Low volumes or sharp variations in volumes are not handled efficiently. Therefore, it is more difficult to develop a competitive slurry pipeline system for commodities such as potash and sulfur.

- Slurry preparation requires large quantities of water. Scarcity of water at the slurry preparation site could negatively affect the system's economics.

Commodity Match

The basic rule is that if a material can be ground to a fine size and mixed with water without impairing its end use, it can be transported by a slurry pipeline. With regard to the Panamanian Isthmus, the major commodity flows relevant to a slurry pipeline system are: phosphates; iron ore; coal; alumina and bauxite; sulfur; and miscellaneous ores, minerals and metals.

Research into the possibility of moving manufactured goods in packaged capsules--in a conveying medium of oil or water--began in the 1950s, and a successful field test has been conducted over a 109-mile distance. A potential commodity is grain. Work was under way in the 1970s on the pneumatic transport of solids in pipelines. One such system, already operating in Japan, uses motorless

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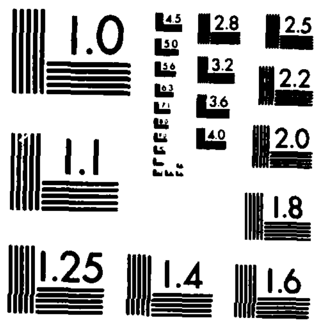


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

vehicles, or gondolas, which ride on wheels inside a pipeline. The vehicles are propelled by an air column at essentially atmospheric pressures.

Table 1

SELECTED MINERAL SLURRY PIPELINES

Location	Year 1st Operated	Length Km	Diameter Cm	Throughput Million Metric tons/yr	Mineral
Tasmania	1967	85	23	2.3	Iron ore
Brazil	1977	395	50	12.0	Iron ore
India	1980	68	46	10.0	Iron ore
Arizona USA	1970	439	45	4.8	Coal
France	1952	82	38	1.36	Coal
Turkey	1973	61	13	0.9	Sulfide
California USA	1971	27	18	1.8	Limestone

OVERLAND CONVEYORS

General Overview

For years, belt conveyors have been used as a primary source to transport bulk materials to storage, from storage, and for in-plant handling. The need to handle larger quantities of materials at a faster pace, with greater efficiency, and with a higher degree of precision and reliability has led to the growing use of overland belt conveyors in place of other modes of transportation.

The belt conveyor dates back to 1891 when the first true belt conveyor handling bulk materials was made. Prior to this time, ordinary transmission belts were used to carry light materials, such as grain, on flat belts over short distances. The belts ran on spool shaped wooden rollers, and because the service was so light, there was no need for great strength or durability in any part of the equipment.

Today, belt conveyors serve rugged applications involving longer distances and with greater lifts than ever before. Both overland and in-plant conveyors are now handling capacities that in the past were considered unrealistic. With the development of the steel cable reinforced belts and computer technology, capacities of 18,000 metric tons per hour (19,836 short tons per hour) and conveyor lengths of 16,000 meters (53,493 feet) are possible and economical.

Technological Overview

For the purposes of this survey, overland conveyors are defined as conveyors that follow the terrain on which they are located and exceed 300 meters (984 feet) in length. Large heavy belt conveyors create unique problems not present in smaller systems. The following are some key factors in system design.

- Belting. For very long conveyors or those with high lift, belt tensions will almost certainly necessitate the use of steel-cable-reinforced belting. Such belting is very long-wearing; however, it is expensive and requires a skilled crew with special equipment for splices.

- Transfer points. Almost all belt wear and damage occurs at conveyor transfer points, so the number of transfers in a system should be kept to a minimum. In addition, each additional conveyor flight represents additional terminal services, drive components, belt turnovers, and chute work, as well as environmental controls and cleanup problems.

- Conveyor drives. A long belt conveyor may require a drive station of several thousand horsepower to overcome the weight of the material being moved and the mechanical friction of the systems. Accurate determination of horsepower and the resultant belt tension envelope is the most important consideration in the design of an overland conveyor. Sophisticated computer analysis is required to determine the steady state, acceleration and deceleration forces. As the conveyor length, mass and power requirements get larger, there is an increasing need to regulate the breakaway and acceleration torques to an acceptable design level and to protect the belt against overload due to equipment malfunctions.

- Shutdowns. Conveyor shutdowns should be planned to allow belts to be emptied before being stopped. For a system of many miles length, a few hours may be required to empty all belts.

- Operation. For efficient operation of the conveyor system, centralized electric control is mandatory. A panel equipped with push buttons and warning lights can provide minute-by-minute control of all moving equipment. A single worker can often run the system.

- Maintenance. Large overland conveyor systems require strong, well-organized preventive maintenance. Belting, idlers and pulleys must be inspected frequently by a highly skilled and specialized crew. A well-stocked warehouse of spare parts is needed for rapid replacement of damaged or worn equipment.

Economic Overview

Belt conveyors are among the most efficient machines ever devised for transporting large quantities of material at a reasonable cost. The economic advantages of belt conveyors include high availability, low labor requirements for

both operation and maintenance (although this advantage recedes somewhat with larger conveyors sytems), low fuel and power requirements, an ability to operate in inclement weather, and minimal environmental impacts.

Disadvantages include very large capital costs, high maintenance costs (parts and equipment), and a lack of operational flexibility. The latter disadvantage relates to startups, shutdowns, and transporting speed, as well as cargo volume, size and weight. The design of a conveyor system is highly dependent on the type of cargo being transported. The engineering and cost factors increase with the variety of the cargo. The system's reliability also decreases with its length, due to the greater number of connections and the greater possibility of problems in a part of the system.

Commodity Match

Overland belt conveyors can be used to transport practically all solid materials, within certain constraints.

- Since a multi-cargo system is likely to be the most appropriate for the Panamanian Isthmus, the cargos should be, or should be capable of being made, generally similar in size (i.e., autos and coal are not comparable on a single system). The largest appropriate commodity groups are minerals and ores.

- Since conveyor systems are not airtight or temperature controlled, commodities such as grain or bananas may be damaged in transit.

As with all transportation alternatives to the Panama Canal, the commodity match for conveyors will be determined by the comparative cost of other systems for each commodity. Part of this cost consideration must be, again as with all land-based alternatives, the comparative cost for each alternative of unloading and loading the commodity off and onto ships.

<u>Future Developments</u>

Although conveyor systems are not a new technology, improvements are being made continuously on the component material, the design, and the control equipment. A conveyor system of the length that would be required for Panama is still experimental, and therefore probably a high risk alternative. Future developments which might improve the feasibility of a trans-isthmian conveyor system would include component parts (or system designs) that are more wear resistant and have greater operational flexibility and cargo handling capability (volume, speed, and variety).

LANDBRIDGE

General Overview

A landbridge consists of that portion of a material movement which occurs over land between two waterborne shipments. Despite the current flurry of interest over substituting segments of waterborne shipments with landbridges, the concept of a landbridge, and its implementation, dates far back in history. To save thousands of miles of travel by water, early traders learned the economic advantages to be gained by changing modes of shipment, traversing a landbridge (e.g., in the areas of the Great Lakes, the Suez, Panama, to name just a few), and reloading the material on ships. In many cases, canals were built to eliminate the necessity to change modes to traverse a landbridge.

The resurgence of the landbridge concept can be attributed to several factors.

- Increasing world trade and ship sizes are exceeding the capacity of present alternatives to the landbridge, such as canals.
- Rising energy costs are making landbridge services more competitive with by-pass shipping.
- The rise in containerized shipments and terminal handling efficiency have increased the compatibility and economic advantages of intermodal transportation systems.
- Unlike earlier transportation landbridges, which crossed narrow strips of land and were geographically limited, modern landbridge operations are capable of crossing the broadest continents at their widest points.

Although nonvehicular transportation systems, such as pipelines and conveyor belts, may fall within the broad definition of a landbridge, current discussions of landbridges concentrate on vehicular modes, particularly railroads and trucks. Consequently, the nonvehicular modes are discussed in separate essays.

Railroads

Technology Overview. The railroad system most amenable to landbridge service is the unit train. The concept of the unit train is simple. It includes a single point of loading, a single destination, a defined routing from origination to destination (avoiding all terminals and switching operations), and intensive train operation (often on set or regular schedules) with minimal loading, in transit, and unloading delays. In practice, unit trains vary significantly as dictated by the requirements of individual commodities and routes. Given the variety of cargo transiting the Panamanian Isthmus, the most likely unit-train landbridge service would consist of either commodity-specific unit trains (e.g., for bulk commodities like coal, using the rotary dump gondola or automated hopper car designs) or a unit train with flatbed cars that could carry containerized cargo. The disadvantage of a bulk commodity-specific train is that if commodity flows are not regular and large, underutilization will result. In addition, the possibilities of back haul cargo are limited. The container unit trains, on the other hand, have the advantage of being able to transport any commodity that can be containerized, and thus are more flexible in scheduling and back haul capability.

The unit train car design is only a part, albeit a very important part, of a broader transportation system which includes terminals at each end. There is a vast range of container transfer terminal sizes and more than one "established concept" of what is the most efficient container transfer system. The system eventually chosen usually depends on the expected container throughput of the location, but a number of other factors, such as the major utilization of the terminal (storage or rapid transit) and the type of surface available, have to be taken into account. For example, in a large terminal, if storage of containers is not a principal activity, but speedy transfer of containers is, a front or sideloader is often suitable as a substitute or back-up device for the traditional crane loader.

Economic Overview

Unit trains achieve intensive equipment utilization by eliminating costly and wasteful switching and terminal costs. The unit-train concept combines specialized railroad rolling stock with improved loading and unloading facilities and streamlined railroad operations. All elements of the unit-train operation (loading, haulage, and unloading) must be in balance and be properly coordinated to eliminate inefficiencies and to guarantee high rates of equipment utilization. Inventory must be carefully controlled. In terms of cost, unit trains are the most efficient method for the railroads to move freight. However, whenever unit-train service deviates from the basic shuttle pattern, its economics deteriorate rapidly (for example, when a railroad permits service outside the shuttle pattern to assemble or distribute cars, or whenever the carrier permits significant changes in the loading schedule).

Commodity Match

As mentioned above, the unit-train landbridge is economically feasible only for large and regular traffic movements. For noncontainerized cargo, single-commodity unit trains are most likely to be used and are most likely to be limited to movements of coal, ores, and perhaps lumber. The system's flexibility and economic advantage increase with containerized cargo.

Future Developments

Among the most prominent new technologies are more stable and efficient locomotives being developed by General Electric and others. The trend in locomotive technology may be toward greater electrification. A smaller number of locomotives will be required than would otherwise be necessary because of the ability to pack more horsepower into a single frame. Air pollutant emission problems will be largely eliminated with electric locomotives.

A substantial number of lightweight cars, each able to carry 10 to 15 percent more load than existing cars, will be in use by 1990. The improved cars will be designed so that high-stress areas will be in areas easily accessible for inspection. A set of transducers and actuators will be employed in order to identify, by sonic and other means, regions that may require repair.

Regenerative power systems (flywheels) will be installed in some areas in order to store the useful work derived from downhill movement for later use. Such systems will reduce locomotive power requirements and improve overall energy efficiency. Canadian National Railways is attempting to improve wheel-tread profiles, while Japan National Railways has developed a method to harden rails and reduce wear via slack quenching.

Significant improvements are already occurring in terminal operations as well. Cargo transfer devices are being developed which are more standardized; have greater speed, accuracy, and weight capacity; and use microprocessing, radio transmission, and laser scanning for remote and automated control. These and future developments are likely to increase terminal throughout capacity and reliability.

Trucks

A landbridge serviced by a trucking mode of transportation is similar in concept to a railroad landbridge. In both cases, the level of technological development is advanced, with future developments relating mainly to marginal modifications in energy efficiency, weight, and structural strength.

The important variables to the utility and feasibility of a truck landbridge are those affecting its operations and infrastructure. Many of these variables are similar to those already outlined for railroads, such as terminal design, loading and unloading facilities, break-even distance, and the handling of containerized vs.

noncontainerized cargo. However, trucks do have several unique characteristics which should be taken into account.

- The quantity of cargo that can be transported by each tractor is highly dependent on the tractor's horsepower, the slope of the terrain, and the weight of the cargo. The maximum number of trailers usually attached to a tractor is 3. This limitation obviously adds to the fuel, equipment and labor costs, and reduces the speed and operational efficiency of trucks. However, if cargo shipments are small or irregular in schedule, tractor-trailers may be a more appropriate mode of transportation than unit trains.

- Tractor-trailer transportation is prone to a higher incidence of mechanical and logistical failures than trains, due to the fact that there are more engines and more transits to be scheduled per given amount of cargo. Consequently, there are likely to be costs associated with frequent maintenance, as well as the necessity of building a highway wide enough to accommodate operational failures in transit.

- Tractor-trailers do have an advantage of flexibility. As long as there is an adequate road network, they can serve a variety of routes between different ports of origin and destination.

AIR CARGO TRANSPORTATION SYSTEMS

A potential transportation alternative to conventional Isthmian transport is use of air cargo systems. While air cargo is usually not currently considered a viable option for all cargoes, it is import to investigate systems which may only become feasible in a long-term perspective. Air cargo transport has gained increased attention as a result of the introduction of intermodal conta[illegible]s. These 20-foot containers conform to International Standards Organ[illegible]on and International Air Transport Association specifications. Currently, th[illegible]e 1,000 containers in use and demand is expected to increase to more than 10,[illegible] by 1985. The Boeing 747F (Frieghter) is the most popular airplane for cargo with 30 in operation, although the wide body designs such as the DC10 and A 300 C4 "Airbus" are also capable of carrying certain designs of containers.

The feasibility of developing a containerized combination air/truck freight distribution system linking mainland Canada and the island province of Newfoundland has been examined for the Gander/Mainland Air Cargo Bridge.

The viable components of the operation consist of a truck pick-up and distribution system linking the shipper/consignee to the air cargo terminals, either a combination "full service" or a container terminal at the airports, and a fleet combination of B747F and L-100 air freighters carrying truck/air intermodal 8' x 8' x 10' and 20' containers. On the Island, one central distribution point at Gander, is located approximately at mid-point on the Island's 500-mile long central highway. Here a combination air/truck terminal is developed. The trucks pick-up and deliver cargo along the highway serving approximately 90 percent of the Island's population with a next day delivery service.

The proposed new service can be profitable charging trucking rates.

While the air cargo transport for Panama would involve an air-sea intermodal system, many of the details of the cycle offer a basis of comparison for any proposed trans-Isthmian system.

Future technological developments in the air cargo transportation involve innovative aircraft designs, including twin and triple fuselage designs. In these systems, the payloads are carried in separate fuselage sections capable of carrying up to 220 tons. In addition, "flatbed" type airlifters have been designed to accomplish multirole missions capabilities with the same basic airframe. This design would enable the airlines to interchange payloads (cargo for passengers). The "flatbed" aircraft is slender in depth with the floor sufficiently close to the ground to permit easy loading. The payloads are carried in individual units moved on and off the basic flatbed aircraft.

This use of air cargo transport may be appropriate for certian containerized cargo that cannot be delayed in transit. However, the economics of these systems make them workable at the present time.

CANAL ALTERNATIVES

PANAMA CANAL MODIFICATIONS

Introduction

The present canal is of the lock type with two lanes of locks at each ocean terminus. The locks raise and lower ships in three steps between ocean level and the higher level of the lake between the termini. At the Atlantic end of the canal, the two lanes each with three lifts are incorporated into one structure. Convenient anchorages are provided near the locks, both on the ocean side and in Gatun Lake on the land side. At the Pacific end, one lift with two lanes (the Pedro Miguel Locks) is provided at the south end of Gaillard Cut where anchoring is not convenient. On the south, the Pedro Miguel Locks open into Miraflores Lake where ships may anchor. The remaining two lifts at the Pacific terminus are the Miraflores two-lane locks. The Pedro Miguel Locks were constructed separate from the Miraflores Locks to reduce construction costs.

The separation of the Pacific Locks into two structures has resulted in several problems. First, an operating crew is required at each structure whereas one crew suffices at the Atlantic Locks. This increases operating costs. Ship transit time is increased by the need to transit two sets of locks. The lack of an anchorage area landward from the Pedro Miguel Locks has hampered the convenient handling of ships. Also, filling Pedro Miguel Locks has caused current surges to travel along Gaillard Cut to the detriment of safe navigation.

The ships are raised and lowered in the locks by the gravity flow of fresh water. Reservoir storage is provided to carry over fresh water from one rainy season to the next. Lockage water for the dry season is provided in this manner. Water is stored in Madden and Gatun Lakes both of which are drawn down to

provide dry season lockage water. The 1970 Interoceanic Canal Study estimated that the existing system could provide enough water to accommodate 17,000 canal transits 9 years out of 10.

The lock chambers, 1,000 feet long and 110 feet wide, limit ship length to 950 feet and beam to 106 feet. Other factors limit draft to 39.5 feet or less. These restrictions generally limit ship size to about 65,000 dwts, although ships up to 95,000 dwts have transited the canal. The limitations prevent the transit of canal by tankers representing a large portion of the world tanker fleet's lifting capacity, as well as by many dry bulkers. Transit by other large ships is also prevented.

The former Panama Canal Company and now its successor, the Panama Canal Commission, have continually maintained and improved the present canal. As a result, the locks, already about 70 years old, are estimated to be operable beyond year 2000. The improvement program has been directed toward facilitating the transit of ships. The 1970 report estimated that replacing the existing locks would cost about $800 million at the prices then prevailing.

The 1968 Kearney report estimated that the present canal would have transit capacity of 26,800 ships a year provided a number of improvement projects were undertaken. The presently estimated transit capacity is 17,500 ships a year. This level of traffic is expected to be reached after year 2000.

A sign of the approaching canal traffic saturation is the increase in the average time that ships spend in canal waters. By 1981, this time had grown to 40.7 hours from 15.4 hours 10 years earlier.

Modification Plans

Many plans have been advanced to modify the present canal to accommodate larger ships and to increase transit capacity. In 1939, the "Third Locks" plan was proposed to accommodate ships up to 110,000 dwts. Construction was started in

1940. Work was terminated in 1942 after expenditure of $75 million because of the other burdens of World War II.

All the plans that have been advanced would increase both the transit capacity and the size of ships that could be accommodated by adding new lanes of locks. The largest lock proposed would accommodate ships up to 250,000 dwts. Also, all plans would use the present locks, the present ship channels and the Third Locks excavations. Most plans would retain or even increase the level of Gatun Lake. Some plans would consolidate the Pacific Locks into a single structure to improve navigation and reduce operating costs. Some plans would also provide a Pacific terminal lake to improve navigation. All plans would include enlarging the existing ship channels.

Lockage water deficiencies in some plans would be overcome by pumping to recycle fresh lockage water or by pumping sea water. Either option would increase both construction and operating costs. In addition, pumping sea water would increase the salinity of Gatun Lake and induce environmental changes there.

A plan which would lower the operating level of Gatun Lake instead of maintaining or even raising its present level was proposed recently by Lopez, Moreno y Asociados, S. A., Panamanian engineering consultants. The plan would lower Gatun Lake level from its present level of 85 feet to 55 feet. The upper lift of Gatun Locks and the entire Pedro Miguel Locks would be eliminated. Elimination of the latter would correct the operation and navigation problems associated with them. The Trinidad arm would be dammed to store lockage water. Lowering Gatun Lake would permit drawing down the water level in Trinidad Lake, thereby increasing its useable storage. In addition to continuing to use the lower two lifts of the locks at the ocean termini, the plan would add two new lanes of locks. One lane would have chambers larger than the present locks and in the other lane the chambers would be smaller. Having three sizes of lock chambers would increase

water usage efficiency. The large locks could accommodate ships up to 250,000 dwts with drafts of 67 feet. All existing ship channels would be deepened and widened requiring about 900,000 cubic yards of excavation, much of it in Gaillard Cut. Some land now flooded in Gatun Lake would be reclaimed while Trinidad Lake would flood land now above Gatun Lake levels.

Modification Costs

The only plan for which up-to-date construction costs are available is the Lopez, Moreno plan which has been estimated to cost $3.5 billion. Other plans have been estimated to cost two-thirds as much as a sea-level canal and $1.5 billion at the price levels prevailing at the time of the estimate.

Offsetting the lesser construction cost of lock canal improvements, when compared to a sea-level canal, is the greater operation and maintenance cost of a modified lock canal. Also, the operation and maintenance cost of a modified lock canal would be greater than the corresponding cost of the present lock canal. Augmenting the lockage water supply would further increase construction as well as operation and maintenance costs.

Cost data for the various plans for modifying the present lock canal are not comparable because the estimates were made at times when different price levels prevailed, because different lock sizes were assumed, and because the plans vary in the improvements to navigation proposed in the area of Pedro Miguel Locks.

Cargo Capacity

Any plan to modify the existing canal to increase its transit capacity and to accommodate larger ships will enhance the capability of the canal to move cargo through it. The ultimate cargo carrying capacity of any canal including the present and improved lock canals depends on the cargo mix, the ship type and size mix

these cargoes might be transported in, the largest ship the canal can accommodate and the annual transit capacity of the canal.

Limitations of Lock Canals

Once the locks for any canal have been constructed, there is no way to enlarge them. To accommodate larger and greater numbers of ships requires that larger locks be built at a substantial cost. Any lock canal is more vulnerable to attack than a sea-level canal. Also, even larger locks would be unable to transit the modern canted-deck aircraft carriers unless the lock is widened substantially or the lift reduced. Either option would increase costs.

Availble Technology

There are no technological constraints to modifying Panama Canal according to the plans that have been advanced. While the lockage water deficiency is serious, the problem can be resolved at the expense of increased construction and operation and maintenance costs and, if sea water is used for this purpose, at the expense of environmental changes.

Feasibility

It is likely that any transportation plan requiring large capital investment will face the same financing problems as a sea-level canal. A key problem is devising a competetive toll structure that would allow construction costs to be amortized within a reasonable time while also paying operation and maintenance costs and royalties to Panama.

SEA-LEVEL CANAL

General Description

A potential transportation alternative to the Panama Canal is the construction of a canal connecting the Atlantic and Pacific oceans. The idea of a sea-level canal is not a new one. In the late nineteenth century, Panama Canal builder, Ferdinand de Lesseps, attempted to build a sea-level canal, but engineering and health problems posed formidable obstacles and prevented construction. However, the concept of a sea-canal did not end there. In 1903 President Theodore Roosevelt's Board of Consulting Engineers was in favor of construction of a sea-level canal but the Senate voted to build the lock canal. In a 1947 study, the Governor of the Panama Canal Zone endorsed the idea of a sea-level canal and in 1960 the President of Panama reviewed the 1947 study and recommended the investigation of the possibility of nuclear excavation of a sea-level canal; in addition a Board of Consultants to the House Committee on Merchant Marines and Fisheries endorsed the necessity of a sea-level canal. In 1964 the Congress set up the Atlantic-Pacific Interoceanic Canal Study Commission to produce a comprehensive engineering survey of possible sea-level canal routes. The Commission produced the "Interoceanic Canal Studies 1970" which concluded that there were "no technical obstacles of sufficient magnitude to prevent successful construction and operation of a sea-level canal." Other major conclusions of the study were that

- the present canal will exceed its estimated maximum capacity of 26,800 transits by the last decade of the century.
- the construction of additional canal capacity should provide for handling ships up to 150,000 dead weight tons (dwts); a

sea level could accommodate ships of 150,000 dwts routinely and 250,000 dwts under controlled conditions.

- a sea-level canal would provide a significant improvement in the ability of the Isthmian waterway to support military operations.

- the sea-level canal in Panama, constructed by conventional excavation either on Route 10 or 14, is technically feasible.

- Route 10 (10 miles west of the present Panama Canal) is the most advantageous sea-level canal route.

- a conventionally excavated sea-level canal on Route 10 with tidal gates, capable of accommodating 35,000 transits each year of representative mixes of ships of the world fleet up to 150,000 dwts, would cost $2.88 billion (1970$).

- a decision to construct a sea-level canal should allow for planning and construction lead time of approximately 15 years to meet the projected date of need.

Technological Description

A sea-level canal is designed for alternating one-way convoy traffic. It would be a single channel, 550 feet wide, with a parabolic bottom 75 feet below mean sea level at the edges and ten feet deeper along the center line. The canal could accommodate ships of 150,000 dwts under all conditions and 250,000 dwts under selected favorable conditions. The ocean approaches would be 1,400 feet wide, 85 feet deep and suitable for two-way traffic with gates to control tidal currents. In addition there would be a tug fleet to assist in navigation. The design of the sea-level canal calls for future construction of a center passing lane to permit two-way convoys in order to increase capacity and eventual two-lane construction from sea to sea.

An initial consideration was the use of buried nuclear devices to excavate a series of large contiguous craters, which by placing a number of devices in a row, would secure a ditch-like excavation. However, in the period since the 1970 study it has been determined that nuclear excavation of the sea-level canal is of doubtful

technical and economic feasibility. In addition the political ramifications of nuclear excavation rule out any possibility of using this method.

Commodity Match

The demands for increase vessel productivity have resulted in larger vessels being constructed in response to reductions in transportation costs per ton mile. This trend has resulted in more ships being unable to transit the Panama Canal. While tankers, dry bulk carriers and container ships account for only half of the number of transits through the Panama Canal, they acccount for 80 percent of tolls and more than 85 percent of overall cargo tons. And while 80 percent of the world's container ships, 85 percent of dry bulk carriers and 70 percent of the tankers can pass through the existing canal, this equals only 20 percent of the world tanker fleet's total carrying capacity, 50 percent of the dry bulk carriers fleet carrying capacity and 50 percent of the container ship fleet carrying capacity. In addition, the increase in average time in canal water has largely been caused by the increase in the number of large ships using the canal. It is increasingly apparent that the existing lock canal is becoming restrictive.

While fleet size may not escalate as much in the 1980s and 1990s as it did in the 1970s, it will still be necessary for the canal to accommodate an increased number of larger ships, and a transportation alternative that could accommodate these ships is desirable. Since the proposed sea-level canal is designed to handle 150,000 dwt ships easily and 250,000 dwt ships under controlled operation, it could handle the number and size of ships in question.

Further, the sea level canal would have some strategic and logistical advantages over the present canal. It could be transited by aircraft carriers, which are too large for the present canal and would be less vulnerable to long-term disruptions by attack.

Economic Feasibility

The critical issue for the acceptability of the sea-level canal is in terms of its costs. The 1970 study indicated that "long-range estimates of potential revenues, construction costs, operating expenses and interest rates are tenuous and subject to unforeseeable charges," especially for the 75-year period needed for its construction and amortization. Further, with a combination of favorable costs, revenues and interest rates, amortization of the estimated 1970 costs could be achieved. However, these favorable conditions have not materialized. Current cost estimates for constructing a sea-level canal in Panama are between \$10-12 billion. Under these conditions the financing of \$12 billion, at interest rates unlikely to fall below 10 percent, over 50 years, would require \$1.2 billion a year in payments (tolls received from the existing canal are presently more than \$300 million/year). Further, there would be royalty payments to Panama, and operating expenses (maintenance, pilotage, operating the tidal and environmental barriers). Also, in contrast to other transportation infrastructure projects, which can be built and used in increments, a sea-level canal would have to be fully financed and built before it could be used. The current situation (interest rates, construction costs, etc.) is such that given the magnitude of the project and recent forecasts of future fleet characteristics, it is likely that costs would be so high that a fully remunerative and price-competitive toll system is impossible. Even with lower or no operating costs, it is likely that high capital costs would prevent a sea-level canal project.

If construction and capital costs are prohibitive for amortizing the facility from tolls, it may be useful to seek alternative financing schemes. Some possibilities include subsidization of costs by the major users, or various combinations of national (Japan, Venezuela, Mexico, United States) or state (Alaska) governments or major companies (oil) guaranteeing bonds to finance a sea-level

canal. Until appropriate financial arrangements can be made, it is unlikely that a sea-level canal will be built.

Environmental Considerations

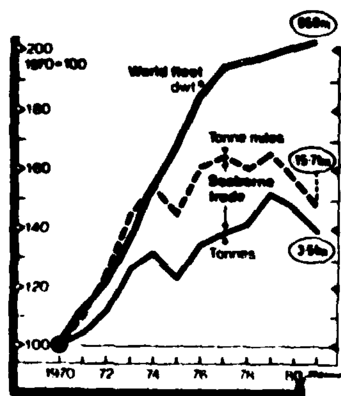
The construction of a sea-level canal is expected to result in ecological changes to the region since it would open a channel for exchange of Atlantic and Pacific waters and the transit of marine life. (The present lock canal has the freshwater Gatun Lake as a barrier.) In addition, the introduction of biota from one ocean into the other may result in severe ecological damage not only locally but throughout the Indo-Pacific and tropical Atlantic regions. Environmental groups point out the need for studies on these subjects prior to any construction of a sea-level canal.

Future Development

While the sea-level canal offers an alternative that can be viable for the types and number of ships in the world fleet through the next century, the issue of technology is not the obstacle to development. Solutions for various environmental considerations, such as faunal movements through the canal and navigational problems caused by tides and currents, can likely be found. Unless innovative financing plans can be developed, the future of the sea-level canal is in doubt.

OCEAN SHIPPING

Ocean shipping has provided the major transport link serving international trade in the past, and it is likely to do so in the future. The global distribution of production, and the resulting effects on the level and composition of world trade are the parameters affecting demand for ocean transport. At the present time, the shipping industry is adjusting to a series of shifts in demand as well as suffering from the sluggish growth of world trade. The past decade witnessed a rapid expansion in tonnage capacity, which was not unmatched by a growth in trade; from 1970 to 1980 seaborne trade (in tons) increased by 44 percent, while shipping capacity rose by some 110 percent (Figure 1). The problem of overcapacity has been particularly acute in the tanker market, where rates have been depressed and many ships are being scrapped well before the end of their useful lives. While new



Source: Fearnley's Review.

Figure 1. Growth of World Fleet and Seaborne Trade

orders for ships have dropped off, it may be well into the 1980s before the surplus capacity is removed. The long useful life of most types of ship (15-25 years) means that technical improvements and changes in design in response to changing cargo demand and operating economics have a delayed impact on the overall fleet. In addition, the prevalence of surplus capacity has depressed new ship orders, further delaying the adaptation of the world's shipping fleet.

Several trends which characterized developments in shipping in the early 1970s have now turned around. The move toward ever larger and faster ships in particular has reached its limits or reversed. Due to the increase in fuel costs, the drive for economy has replaced that for greater speeds. Many new vessels are powered with slower, more economical diesel engines instead of gas turbines. Indeed owners have even found it profitable to re-engine existing gas turbine-powered vessels with diesels. Operating economies are such that the decrease in available capacity from slower sailing is more than offset by the lower cost of bunkering. In the future, further increases in petroleum prices could lead to a renewed attractiveness of coal as a boiler fuel. In addition to power requirements, increased attention has been devoted to developing new bottom coatings to reduce fouling and improve fuel economy.

For a number of reasons, the trend towards ever larger unit sizes in shipping that characterized the early part of the past decade has either leveled off or reversed. Table 1 shows the average size of ships on order for recent years, showing steady increases only for containerships and bulk carriers. Particularly evident is the decline in the number of large (over 150,000 dwt) tankers on order, in addition to with the decrease in average size. Very large and ultra large crude carriers have proved to be of only limited use because of a lack of suitable port facilities, and have suffered acutely from the overcapacity plaguing the tanker market. Many that were built in the early-mid-1970s are now being scrapped

Table 1

NEW SHIPS ON ORDER, 1977-1982
Average Size, Tons D.W.
(Number of Ships in Parentheses)[1]

	1977 (April)	1978 (April)	1979 (August)	1981 (August)	1982 (July)
Dry Cargo	(1,590) 9,942	(1,371) 9,139	(980) 8,261	(690) 8,119	(654) 7,691
Containerships	(288) 12,878	(346) 11,580	(341) 13,430	(203) 15,064	(233) 15,956
Tankers (over 150,000 dwt)	(98) 271,600	(54) 264,443	(35) 250,462	(16) 217,788	(8) 250,538
Tankers (other)	(435) 39,661	(386) 38,750	(452) 40,691	(574) 35,064	(408) 32,873
Ore/Oil and Ore/Bulk/Oil	(41) 111,510	(28) 107,892	(20) 102,400	(46) 92,567	(36) 92,314
Bulk Carriers	(721) 37,381	(441) 34,634	(314) 36,559	(696) 52,490	(654) 51,238
Total	(3,173) 29,912	(2,626) 24,398	(2,142) 24,912	(2,225) 32,837[2]	(1,993) 30,606[2]

Source: "World Ships on Order," Supplement to Fairplay; Fairplay World Shipping Yearbook.

Notes: 1. Includes only ships for which tonnage figures were available.

2. Figures for 1981 and 1982 exclude Passengers and Ferries, and Miscellaneous from totals.

prematurely or are used as storage facilities. While the trend towards large supertankers has reached its limits, the economic size for crude tankers on long ocean routes is still above Panamax size, or the largest size ship which can transit the Panama Canal (approximately 80,000-90,000 dwt). For the major oil route that utilizes the Canal, Alaskan-U.S. Gulf Coast and U.S. East Coast, Atlantic Richfield constructed three new tankers of 120,000 dwts, and considers only tankers of over 100,000 dwts as suitable for West Coast service. Other companies taking out Alaskan oil also use large tankers for the Prudhoe Bay-Balboa voyage. Oil is then transhipped through the Canal on smaller tankers for delivery to Gulf and East Coast ports. The ease of offloading crude oil, either into smaller ships or into pipeline terminals, partially alleviates the constraining effects that Panamax size limitations would otherwise impose on the shipment of crude oil across the Isthmus. The flexibility of transhipment arising from the facility of handling crude oil cargoes has allowed the utilization of large tankers for the West Coast segment of the Alaskan oil route. For other cargoes, primarily dry bulk, the size limitations of the Canal do pose constraints.

The trend in new bulk carriers on order has shown an increase in average size, primarily over the past two years. The increase in tonnage on order and the increase in average size reflected the anticipation of shipowners of increased demand arising from coal exports by the United States. A large number of the new ships are being designed to Panamax dimensions, with over 185 Panamax bulk carriers on order at the end of 1981. While the trend has been toward larger average size, most ships designed have not exceeded Panamax dimensions. The flexibility demanded of bulk carriers makes it propitious for shipowners to restrict their vessels to Panamax size out of concern for resale value and the potential need for repositioning vessels on new routes.

In the containership sector, there is a significant trend towards larger ship sizes, but with average levels still well below Panama's scale. This contrasts with a steady decline in the average size of general dry cargo ships. The smaller average size of containerships and general cargo ships reflects the demands of the routes they serve and the limitations of port facilities. The increasingly widespread utilization of container port facilities with larger berthing space has been one factor encouraging larger vessel size. The trend toward increased containerization of general cargoes is at a mature stage in trade among the OECD countries. The increase in cargo handling efficiency available through containerization has drastically reduced the loading/off loading time required in port. Over the long run it is likely that the break-bulk sector of the general cargo market will be increasingly eroded by containerization on one end and by greater bulk carriage on the other, largely due to the inefficiency of handling break-bulk cargoes. The greatest potential for further containerization lies in trade with developing countries. However, the lack of adequate infrastructure to handle containers in developing countries will pose an obstacle to increased utilization. Thus, it is likely that the trend to fully cellular, container-only vessels and completely automated cargo handling will continue to be gradual.

The increased efficiency of cargo handling achievable through containerization, and also through improved means of bulk cargo handling, have introduced new elements of flexibility into shipping requirements. Container ports serve as intermodal transport hubs, where the same terminals link deep-sea containership berths with short-sea feeder facilities and rail and trucking depots. The increasing routing of trade through major regional container ports will facilitate the use of larger ships on the ocean passages between these ports, without the size constraints of serving smaller ports on direct routes. Thus, it is possible in the future that containership sizes may be constrained by Panamax dimensions for those cargo

routes utilizing the Canal. However, the automation in cargo handling which makes the transfer of containerized cargo to large ships for ocean passages feasible also facilitates the use of alternate modes for trans-Isthmian transport based on the landbridge concept.

The design of oceangoing vessels has always been limited by the facilities of the ports they are intended to serve. The economics of operation at sea assumed a secondary role as determinant of ship design. Indeed, there has been greater return in terms of the overall efficiency of shipping from improvements in cargo handling than improvements in at-sea operating characteristics. Only in large crude carriers did pure economies of scale in operation take precedence over the restrictions of port size, because of the ease of cargo transfer. Improvements in port facilities have spurred the growth of vessel size in both the bulk and containerized cargo sectors. For containerships, Panamax size limitations will be a constraint in the future on the size of vessels. However, it is in the bulk cargo sectors, which represent the majority of present and future Canal traffic, that vessel design is already, and will continue to be, constrained by the limitations of the Canal. The large bulk carriers serving on routes outside the Canal and the substantial number of new bulk carriers of Panamax size on order are evidence of this. While the current glut of ships on most markets may defer new ship orders and thus delay changes in world shipping fleets, within the time span of this study a significant turnover in the fleet will be effected. The changes which are likely to occur will be constrained by Panama Canal size limitations in the bulk trades and, potentially, in the containerized trade.

Appendix A

CONSENSOR VOTES

CONSENSOR VOTE

QUESTION: "WILL THE PANAMA CANAL BE ADEQUATE IN THE YEAR 2010?"

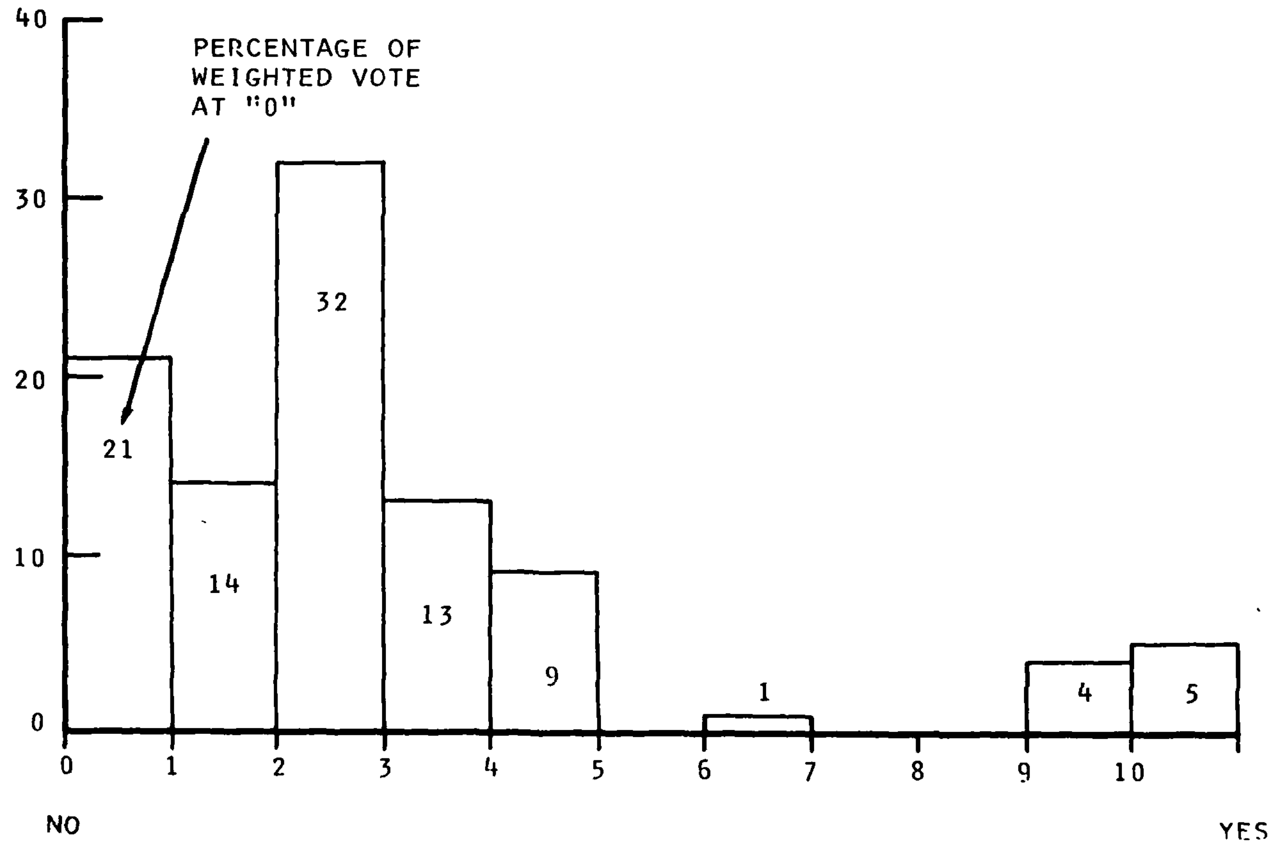
FIRST VOTE

AVERAGE VOTE

MEAN
2.4

WEIGHT
80%

GROUP CONFIDENCE IN ANSWER



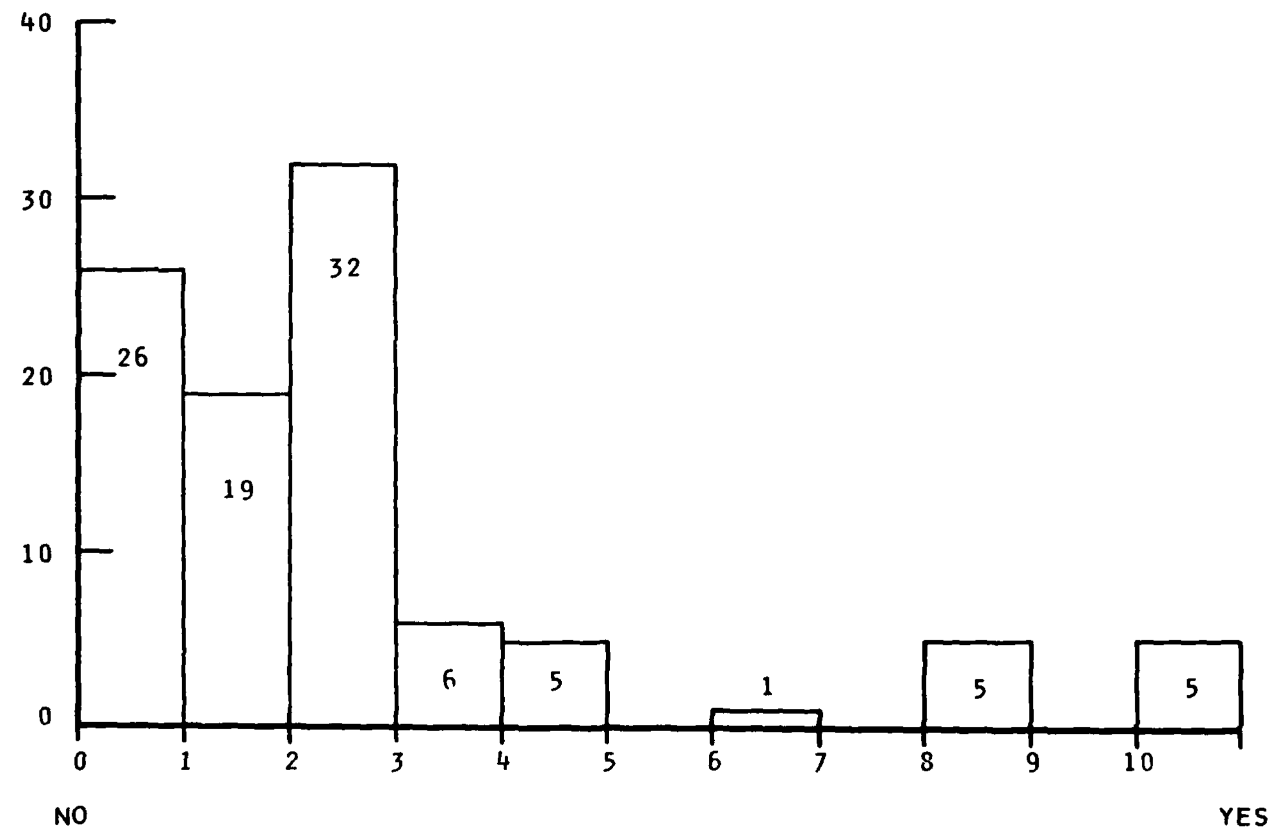
CONSENSOR VOTE

QUESTION: "WILL THE PANAMA CANAL BE ADEQUATE IN THE YEAR 2010?"

<u>SECOND VOTE</u>

MEAN
2.1

WEIGHT
82%



Appendix B

PARTICIPANT LIST

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